Allen-Bradley

ControlNet PLC-5 Hot Backup System

(Includes Cat. No. 1785-CHBM)

User Manual

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. *Safety Guidelines for the Application, Installation, and Maintenance of Solid State Controls*, publication SGI-1.1 describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

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The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, the Allen-Bradley Company cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual we use notes to make you aware of safety considerations.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

Attentions help you:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is especially important for successful application and understanding of the product.

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Using This Manual

Manual Objectives

This manual shows you how to use the ControlNet PLC-5 Backup system. This backup system uses a pair of standard PLC-5/40 or PLC-5/80 ControlNet processors (Series F, Revision A or higher), with I/O remotely connected to the processors via ControlNet.

Note: For the ControlNet PLC-5 processors to operate in backup mode, each processor must have the new ControlNet Backup Cartridge (Cat. No. 1785-CHBM) inserted into its EEPROM memory module slot.

Using ControlNet, the PLC-5 processors communicate with each other and with ControlNet remote I/O to create a PLC-5 backup system that provides high availability of control applications, where it is essential for process continuity to be high.

In this manual, we describe:

- backup system concepts
- hardware and software components required for the system
- procedures for installing and configuring the system
- operation of the backup system
- troubleshooting diagnostics/procedures for the backup system

Who Should Use This Manual

Before you read this manual or attempt to use the ControlNet PLC-5 backup system, you should be familiar with the use and operation of ControlNet PLC-5 processors. You should also be familiar with:

- remote I/O
- the ControlNet network
- RSLogix 5 programming software
- RSNetWorx for ControlNet software
- RSLinx communications software

What This Manual Contains

Refer to the following table to guide you through the information contained in this manual. In this manual, we describe:

For information on:	Refer to chapter/appendix:
concepts for using a backup system in a ControlNet system; basic system architecture	1 - Backup Concepts for the ControlNet PLC-5 Backup System
the hardware and software components required for a backup system	2 - Understanding the ControlNet PLC-5 Backup System Components
installing backup system components; configuring the backup system	3 - Installing and Configuring Your ControlNet PLC-5 Backup System
the diagnostic capabilities of the backup system; troubleshooting tips for the backup system	4 - Monitoring and Troubleshooting Your ControlNet PLC-5 Backup System

For information on:	Refer to chapter/appendix:
specifications for the 1785-CHBM module	A - Specifications
backup states and backup state transitions	B - Backup States
the data table crossloading feature	C - Data Table Crossloading
the program synchronization feature	D - Program Synchronization
application examples; items to consider while operating the backup system	E - Application Guidelines
reference information on the ControlNet backup module for users familiar with the Allen-Bradley 1785-BCM systems	F - Comparison to the 1785-BCM System

Related Publications

For more information about components used with the ControlNet PLC-5 backup system, refer to the following publications:

PLC-5 Processor Documentation

Publication Title	Publication Number
1785 Enhanced PLC-5 Processor System Overview	1785-2.36
ControlNet PLC-5 Programmable Controllers User Manual	1785-6.5.22
ControlNet PLC-5 Programmable Controllers Quick Start	1785-10.6
PLC-5 Programmable Controller Flash Tool User Manual	1785-6.2

ControlNet Documentation

Publication Title	Publication Number
ControlNet System Overview	1786-2.12
Industrial Automation Wiring and Grounding Guidelines	1770-4.1
ControlNet Cable System Component List	AG-2.2
ControlNet Cable System Planning and Installation Manual	1786-6.2.1
ControlNet Coax Tap Installation Instruction	1786-2.3
ControlNet Network Access Cable Installation Instructions	1786-2.6
ControlNet Repeater Installation Instructions	1786-2.7

For more information on any of the software components of the ControlNet PLC-5 backup system (e.g., RSLogix 5, RSLinx, and RSNetWorx), refer to the software documentation and online help for the individual software packages.

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Backup Concepts for the ControlNet PLC-5 Backup System

Chapter Objectives

This chapter describes concepts for using a backup system with your programmable controller. In particular, this chapter describes the use of the ControlNet PLC-5 backup system, including its basic system architecture.

Why Use a Backup System?

The objective of any redundant system (i.e., backup system) is to improve the amount of up-time of a machine or process by ensuring consistent availability of that machine, thereby reducing costs associated with equipment failure. By using this backup system, you can help guard your application against shutdowns caused by the programmable controller.

ATTENTION: When using identical programs in both PLC-5 processors, using a backup system does not necessarily protect you from faults caused by programming errors or system timeouts. Such errors or timeouts can also occur in the secondary processor. Be certain to carefully check your programming, and to thoroughly check redundant operations before implementing the backup system.

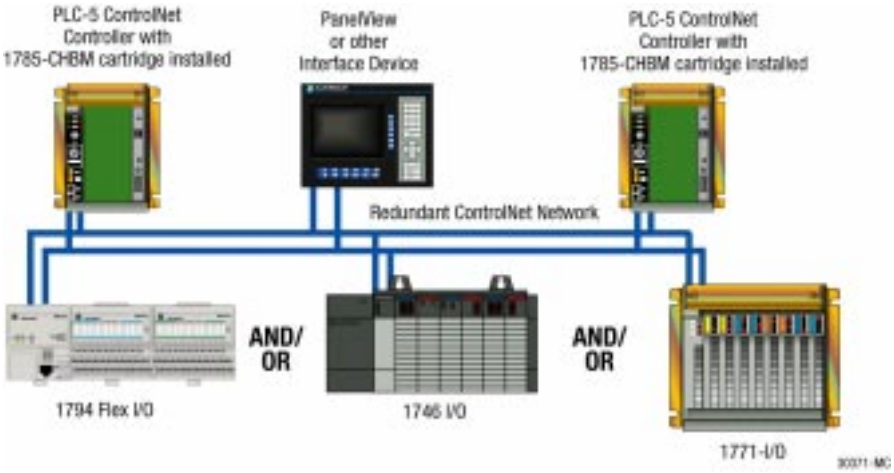
The backup option is used where you must transfer the control of the process to a secondary system without interrupting the machine/process operation.

To guard against system shutdown, a backup system must provide:

- equipment with exceptional reliability
- automatic fault isolation
- minimal disturbance of the process when switching from the primary to the secondary system

Basic System Architecture

This section describes the various components of the basic ControlNet PLC-5 backup system. The following picture illustrates the basic backup system.



How the Backup System Works

In a ControlNet PLC-5 backup system, one PLC-5 processor, referred to as the primary processor, controls the operation of the ControlNet I/O. The other processor, referred to as secondary, is set up to take control of the ControlNet I/O in the event of a fault in the primary processor.

The ControlNet network is wired to both PLC-5 processors, as well as to all ControlNet I/O in your system. Using ControlNet, the processors communicate (or “handshake”) with each other, exchanging status information on their operational states. If the primary processor faults, or is otherwise unable to continue control of the outputs, the secondary processor assumes control and becomes the primary.

Both PLC-5 processors are actively connected to the ControlNet I/O, receive all input data sent by the I/O adapters, and then use that data as they execute their program scans. Output data is sent via ControlNet from both processors. However, only data from the primary processor is used by the I/O adapter(s).

In the case of the ControlNet PLC-5 backup system, there are several features to consider that, though common to many backup systems, are uniquely implemented in this particular system. Understanding these features and their functions will help you in the design and implementation of your backup applications.

Qualification

When bringing the secondary processor of a backup system online, it is important to ensure that it is in a state that will enable it to take over the control of the system in the event of a primary failure or switchover. This process of verifying and conditioning the state of the secondary processor is known as qualification. Switchover will not occur without a qualified secondary processor; the backup system is not truly considered a backup system until the secondary processor has successfully completed qualification.

The qualification phase includes several tests and verifications between the primary and secondary processors, as well as data file crossloading. You can tailor these tests, verifications, and data file crossloads to ensure the level of system integrity required for your application. These tests and verifications may cover:

- configuration file validity and integrity checking
- application program and data file structure equivalence checking
- I/O map structure comparison
- force table comparison
- status file comparison

Data file crossloading from the primary to the secondary processor may include the transfer of integer values, floating point values, timers, counters, PID values, and others you define.

Equivalence Checking

Backup systems are traditionally designed in a way such that both the primary and secondary processors are programmed with identical applications. This allows for the controlled process to continue with normal production operation in the event of a primary processor failure. Equivalence checks ensure that the primary and secondary processors have identical ladder programs, data file structures, I/O map structures, etc.. You, as the designer of the backup system, require the ability to enforce equivalence checks between the primary and secondary processors during the qualification process, and periodically during normal production operation.

In some cases, you may want the secondary processor to have a completely different application than the primary processor (e.g., “safe shutdown,” limited production, clean and wash, etc.). In that case, equivalence checking may not be required. With the ControlNet PLC-5 backup system, you can enable or disable equivalence checking as required by your application. You must have a thorough understanding of your application in order to make this determination.

Bumpless Transfer

Ideally, when a processor switchover takes place in the backup system, there should be no adverse effect on system operation, and the controlled process should continue to run as though it were still being controlled by the original primary processor. This is generally referred to as a bumpless transfer of control.

Bumpless transfer is not required for many backup applications, but it is highly desirable. Divergence in program scanning, I/O tables, data tables, and long switchover times can all cause bumps when transferring control from a primary to a secondary processor. The ControlNet PLC-5 backup system allows you to choose synchronous program scan operation, as well on-demand crossloading of data table files you select. These options can greatly reduce the possibility of bumps during a processor switchover.

Switchover

Switchover is what occurs when the secondary processor assumes control of the process, thus becoming the primary processor. Several conditions can cause this to happen:

- critical failures in the primary processor (e.g., hardware faults)
- internal conditions within the primary processor (e.g., a major fault), causing it to relinquish control of the process to the secondary processor
- external conditions recognized by the secondary processor (e.g., loss of communications with the primary processor) causing it to assume control of the process
- a manual switchover (i.e., a forced switchover, where you cause the secondary processor to become primary, and vice versa; you may choose to do this when testing your system for backup performance and integrity, or as part of a system maintenance program).

The ideal switchover time from the primary processor to the secondary processor would be instantaneous. The ControlNet PLC-5 backup system typically provides a switchover time of 30-50 ms. This time is adequate to avoid a bump in most systems, but you should determine the maximum allowable switchover time for your applications.

Understanding the ControlNet PLC-5 Backup System Components

Chapter Objectives

This chapter describes the components that make up the ControlNet PLC-5 backup system.

Hardware Components

These components include:

- two Series F PLC-5 ControlNet processors (either 1785-L40C15/F or 1785-L80C15/F)

  Each processor must be in a separate 1771 chassis, and each chassis must have its own power supply. Various chassis and power supplies are available; choose them based upon standard 1771 and 1785 selection and installation criteria.

  Note: Though we do not recommend it, it is possible for you to use a mixed set of processors as a backup pair (e.g., one PLC-5/40 and one PLC-5/80).

- two 1785-CHBM/A ControlNet backup cartridges (one for each PLC-5 processor)
- two 1771 chassis (one for each PLC-5 processor)
- two 1771 power supplies (one for each chassis)

  You can elect to use redundant power supplies within a chassis if you wish. We do not recommend the use of I/O within the chassis, since provisions for backing up the local I/O are not provided.
- one or more ControlNet I/O adapters
- ControlNet network cables, taps, and terminators for making connections between the PLC-5 processors and the I/O adapters
- a PC with a 1784-KTCX15 card, or a laptop computer with a 1784-PCC card
- other ControlNet devices, including HMI (optional)

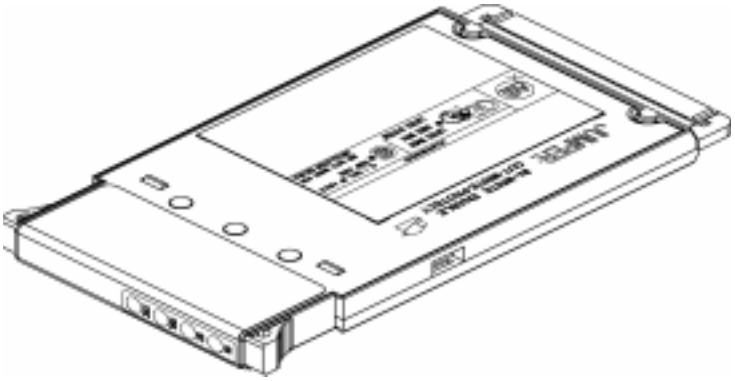
Software Components

The basic ControlNet PLC-5 backup system includes the following software components:

- RSLogix 5 programming software (Release 3.21 or later)
- RSNetWorx for ControlNet software (Release 1.08 or later)
- RSLinx gateway communication software (Release 2.00.97.30 or later)

ControlNet Backup Cartridge

Each ControlNet PLC-5 processor requires a 1785-CHBM/A ControlNet backup cartridge, inserted into the PLC-5 EEPROM memory cartridge slot, to enable backup functionality.



The ControlNet backup cartridge contains EEPROM memory cartridge functionality (i.e., the cartridge can also be used as a standard PLC-5 EEPROM memory storage cartridge for the PLC-5 processor, with up to 100K of memory).

Important: The 1785-CHBM ControlNet backup cartridge cannot be used with non-backup PLC-5 processors.

Installing and Configuring Your ControlNet PLC-5 Backup System

Chapter Objectives

This chapter outlines the steps you must perform to install the backup system components, and to subsequently configure them to create a functioning backup system.

Installing the Hardware

Before you begin, be sure that you have all of the required hardware components, as listed in Chapter 2.

Follow these steps to install the required hardware for your backup system.

1. Set the ControlNet node address number for each of the PLC-5 processors.

   Important: The node addresses must be consecutive, with the lower number being odd. For example, a valid node address pair is 1 and 2. You set the ControlNet node address via the rotary switches on the top of each processor. You may need to change the ControlNet node address of other devices so that you have two consecutive addresses available on your ControlNet network.
2. Install each PLC-5 processor into a separate 1771 chassis.
3. Insert the 1785-CHBM ControlNet backup cartridge into the EEPROM slot of each PLC-5 processor. (Note that the power must be OFF on the processor before you do this.)

   Important: If the ControlNet backup cartridge is not inserted into the PLC-5 processor, that processor will operate as a normal, standalone processor, and will not exhibit any of the necessary backup functions.
4. Install a power supply for each chassis, and connect to ac power.
5. Wire the ControlNet network to the PLC-5 processors and to the ControlNet I/O adapters being used for the backup system.

   The network cabling may consist of single or redundant channels.

   Important: In non-redundant media applications, place your two PLC-5 processors as the 2 nodes closest to a terminator on a ControlNet segment. This eliminates the possibility for a malfunctioning cable between the processors to allow each processor to control a subset of the I/O.
6. Basic installation is now complete. Set the keyswitch to Program mode on each processor and apply power to the processors.

Configuring Your Backup System

Before you begin, make sure that you have installed RSLinx, RSLogix5, and RSNetWorx for ControlNet software. For assistance with installing any of these packages, refer to their respective installation documentation.

There are two basic configuration paths. Select the appropriate path based upon the type of backup system you are creating.

- If you are creating a backup system with identical (or nearly identical) control applications in the primary and secondary controllers, complete the steps in the section of this chapter entitled “Configuring With a Single Control Application.”
- If you are creating a backup system where the secondary controller is running a different application than the primary, complete the steps in the section of this chapter entitled “Configuring With Different Applications.”

Configuring With a Single Control Application

This section assumes that you have already developed your control application and have loaded it onto a single ControlNet PLC-5 processor (i.e., a non-backup system). Throughout this section, we will refer to this processor as the first processor. Furthermore, we assume that you have a second processor installed, powered on, and in its default state. Both processors must be in Program mode and must be physically connected to your ControlNet network.

To create and configure your backup system under these circumstances, complete the following steps:

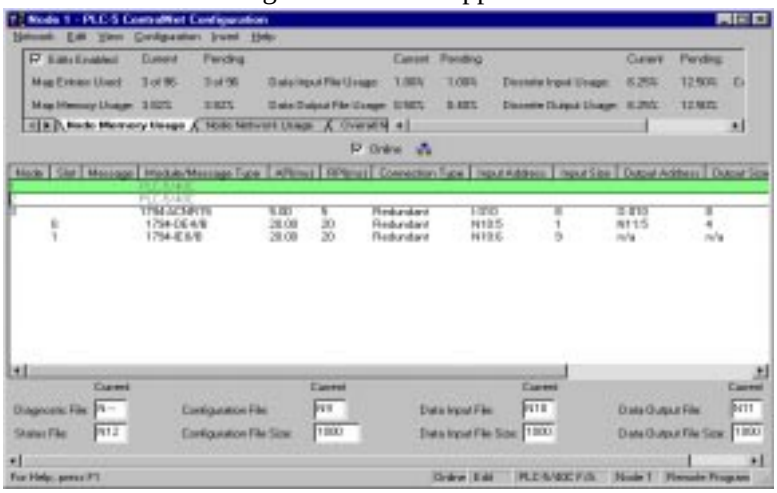
1. Reconfigure ControlNet I/O on the first processor.
2. Configure handshaking messages between both processors.
3. Configure ControlNet I/O on the second processor.
4. Save the ControlNet configuration.
5. Configure the hot backup parameters on the first processor and save the project.
6. Create and download the project for the second processor and save the project.

Reconfigure ControlNet I/O on the First PLC Processor

Reconfigure all ControlNet I/O adapters and modules that will be in your ControlNet PLC-5 backup system by changing their ControlNet connection from Exclusive Owner (default) to Redundant.

1. Launch RSNetWorx for ControlNet.
2. Check the Edits Enabled checkbox on the toolbar.
3. Right click on the first PLC-5 processor (the odd node) and choose ControlNet Configuration.

   The ControlNet Configuration screen appears.



4. For each entry under the Connection Type column, double click on Exclusive Owner, choose Redundant from the pull-down menu, and press Enter.

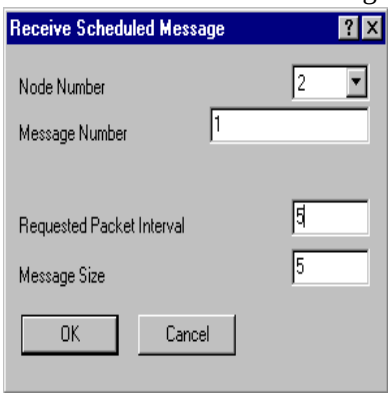
Configure Handshaking Messages With RSNetWorx

Within your backup system, you must use RSNetWorx to set up the send and receive scheduled messages that allow handshaking to occur between the two ControlNet PLC-5 processors that comprise your backup system.

For each of the processors comprising a backup system, you must create two scheduled peer-to-peer messages: one Send and one Receive. These messages must be exactly five words in length. From the ControlNet Configuration screen for the first processor, follow these steps:

1. Right click on the even node (Node 2 in this example) and choose Insert Receive Scheduled Message.

The Receive Scheduled Message dialog appears.



The Node Number field is already filled in for you. This number indicates the node number from which you will receive the Receive scheduled message. In your ControlNet backup system, the odd node will receive the message from the even node, and vice versa.

2. Enter the message number you wish to assign to identify this message.

   Note that the message number for the Receive message must match the message number of the corresponding Send message. The node number and message number are used together to identify the specific message.

3. In the Requested Packet Interval field, enter an RPI value for this message from 1 to 32,767. (For purposes of this example, we will use an RPI value of 5.)

   In general, the RPI value must be no less than the NUT value, but less than 2 times the NUT value. This value must be the same in both PLC-5 processors.

4. In the Message Size field, enter a value of 5 and click OK.

   The Receive scheduled message is inserted in your ControlNet Configuration for the odd node. The corresponding Send scheduled message is automatically inserted for the even node.

5. From the main RSNetWorx screen, right click on the second PLC-5 processor and choose ControlNet Configuration.

6. Right click on the odd node (Node 1 in this example) and choose Insert Receive Scheduled Message.

   The Receive Scheduled Message dialog appears. The Node Number field is already filled in for you. This number indicates the node number from which you will receive the Receive scheduled message. In your ControlNet backup system, the odd node will receive the message from the even node, and vice versa.

7. Repeat steps 2 through 4, creating a Receive Scheduled Message for the even node.

8. Record the Send and Receive message numbers from the odd processor node below:

   Send message number:_____

   Receive message number:_____

   You will use these numbers later in the configuration process.

Configure ControlNet I/O on the Second PLC Processor

Configure all ControlNet I/O adapters and modules that will be in your backup system, and ensure that the ControlNet I/O mapping and data file assignments on the second processor match those on the first.

1. From the ControlNet Configuration screen (for the second processor), right click on the node corresponding to your I/O adapter and choose Auto Module > Selected Device.

   All 1794 non-discrete I/O modules on your ControlNet network are added to your configuration as pending map entries.

2. Enter data table file addresses for the Diagnostics, Status, Configuration, Data Input, and Data Output files.

   Note that these addresses must be the same for both processors. Be careful to enter file numbers which do not conflict with existing data table files.

3. Select each adapter and module in the backup system and enter the data table address that matches the address assigned on the first processor.

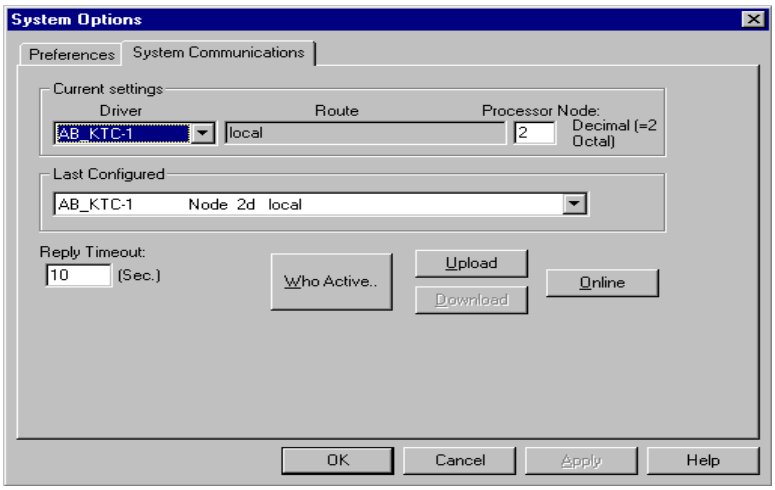
4. From the Network menu, choose Save to save the completed ControlNet configuration.

Configure the Hot Backup Parameters

1. Launch RSLogix 5.

2. From the Comms menu, choose System Comms...

   The System Options dialog appears, with the System Communications tab selected.



3. In the Processor Node field, enter the node number of the first processor.

4. Click on the Online button to connect to the processor.

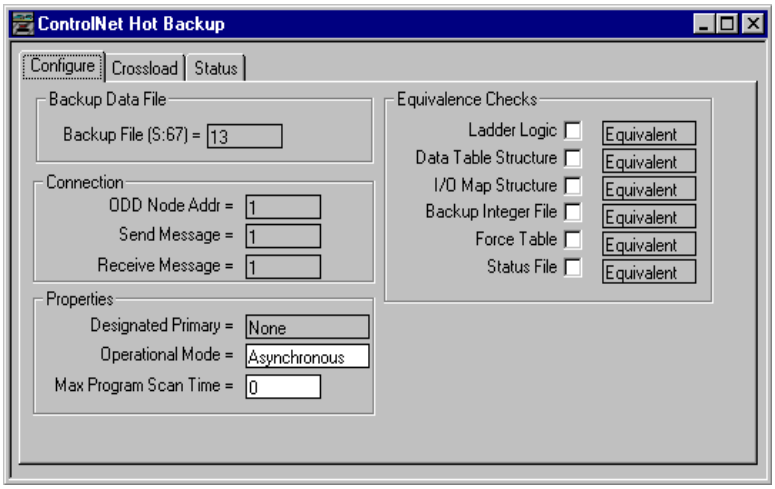
5. When prompted, click on OK to confirm that you wish to complete the upload.

   This step is required since you have made changes to the ControlNet configuration.

6. From the File menu, choose Save to save the project.

7. Click on the Hot Backup icon under the Controller folder to launch the Hot Backup Configuration utility.

   The ControlNet Hot Backup screen appears, with the Configure tab selected.



8. Set the following:

   - Backup File - Enter an unused data file number. This creates a 200-word integer file to be used as the ControlNet Backup Configuration and Status file.
   - Odd Node Address - Enter the ControlNet node address corresponding to the odd node processor.
   - Send Message - Enter the message number of the Send Scheduled Message from the odd node address. (Refer to the number you recorded earlier.)
   - Receive Message - Enter the message number of the Receive Scheduled Message from the odd node address. (Refer to the number you recorded earlier.)

   If your system is properly configured, the PRI and SEC LEDs on the first processor's backup cartridge are off.

9. Save the configuration.

   This completes the backup configuration for the first processor.

Create and Download the Project for the Second PLC Processor

The next step in configuring your system is to duplicate the fully-configured project from the first processor and apply it to the second processor.

Important: You must keep the ControlNet configuration you create for the second processor, since it is not completely identical to that of the first processor.

1. In RSLogix 5, open the project associated with the first processor offline.
2. From the File menu, choose Save As, and save the project under a new name to be associated with the second processor.
3. From the Comms menu, choose System Comms and change the processor node value from the current standalone processor to the other processor of the odd-even pair (e.g., if the standalone processor was processor 1, change the value from 1 to 2.)
4. From the Comms menu, choose Download to download the project to the new processor.
5. When prompted to decide whether you wish to keep the existing ControlNet configuration, choose Yes.

   Note: This is not the default option.
6. Go online with the new processor.
7. From the File menu, choose Save to save the project.

   The QUAL LED on both processors should now be yellow, and you have a fully qualified backup system. If desired, you can now go to Run mode.

Configuring With Differing Applications

This section assumes that:

- you intend for the secondary controller in your backup system to run a different application than the primary
- you have already developed separate control applications for the primary and secondary processors
- the control applications are loaded onto their respective processors
- both processors are powered on, are in Program mode, and are physically connected to the ControlNet network
- you have not yet configured these processors to function within a backup system

To create and configure your backup system under these circumstances, complete the following steps:

1. Reconfigure ControlNet I/O on the first processor.
2. Configure handshaking messages between both processors.
3. Reconfigure ControlNet I/O on the second processor.
4. Save the ControlNet configuration.
5. Configure the hot backup parameters on the first processor and save the project.
6. Configure the hot backup parameters on the second processor and save the project.

Reconfigure ControlNet I/O on the First PLC Processor

Reconfigure all ControlNet I/O adapters and modules that will be in your ControlNet PLC-5 backup system by changing their ControlNet connection from Exclusive Owner (default) to Redundant.

1. Launch RSNetWorx for ControlNet.
2. Check the Edits Enabled checkbox on the toolbar.
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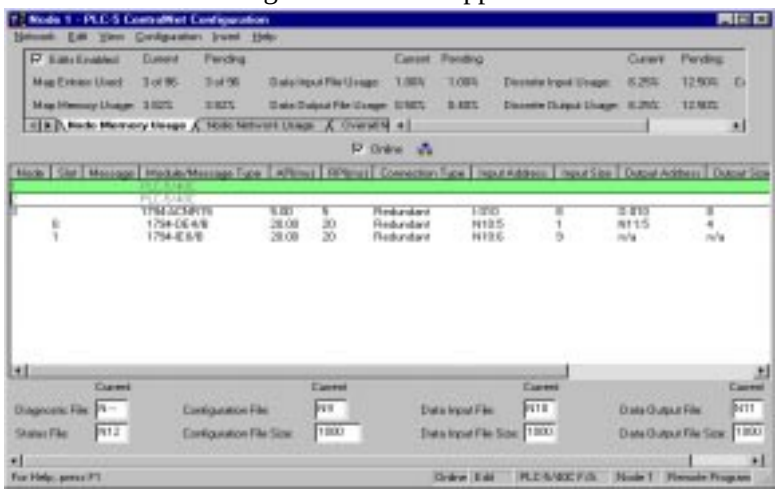


4. For each entry under the Connection Type column, double click on Exclusive Owner, choose Redundant from the pull-down menu, and press Enter.

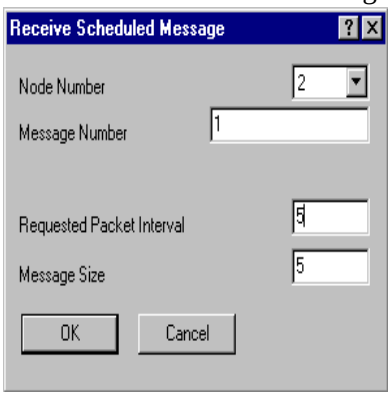
Configure Handshaking Messages With RSNetWorx

Within your backup system, you must use RSNetWorx to set up the send and receive scheduled messages that allow handshaking to occur between the two ControlNet PLC-5 processors that comprise your backup system.

For each of the processors comprising a backup system, you must create two scheduled peer-to-peer messages: one Send and one Receive. These messages must be exactly five words in length. From the ControlNet Configuration screen for the first processor, follow these steps:

1. Right click on the even node (Node 2 in this example) and choose Insert Receive Scheduled Message.

   The Receive Scheduled Message dialog appears.



   The Node Number field is already filled in for you. This number indicates the node number from which you will receive the Receive scheduled message. In your ControlNet backup system, the odd node will receive the message from the even node, and vice versa.

2. Enter the message number you wish to assign to identify this message.

   Note that the message number for the Receive message must match the message number of the corresponding Send message. The node number and message number are used together to identify the specific message.

3. In the Requested Packet Interval field, enter an RPI value for this message from 1 to 32,767. (For purposes of this example, we will use an RPI value of 5.)

   In general, the RPI value must be no less than the NUT value, but less than 2 times the NUT value. This value must be the same in both PLC-5 processors.

4. In the Message Size field, enter a value of 5 and click OK.

   The Receive scheduled message is inserted in your ControlNet Configuration for the odd node. The corresponding Send scheduled message is automatically inserted for the even node.

5. From the main RSNetWorx screen, right click on the second PLC-5 processor and choose ControlNet Configuration.
6. Right click on the odd node (Node 1 in this example) and choose Insert Receive Scheduled Message.

   The Receive Scheduled Message dialog appears. The Node Number field is already filled in for you. This number indicates the node number from which you will receive the Receive scheduled message. In your ControlNet backup system, the odd node will receive the message from the even node, and vice versa.
7. Repeat steps 2 through 4, creating a Receive Scheduled Message for the even node.
8. Record the Send and Receive message numbers from the odd processor node below:

   Send message number:_____

   Receive message number:_____

   You will use these numbers later in the configuration process.

Reconfigure ControlNet I/O on the Second PLC Processor

Reconfigure all ControlNet I/O adapters and modules that will be in your ControlNet PLC-5 backup system by changing their ControlNet connection from Exclusive Owner (default) to Redundant.

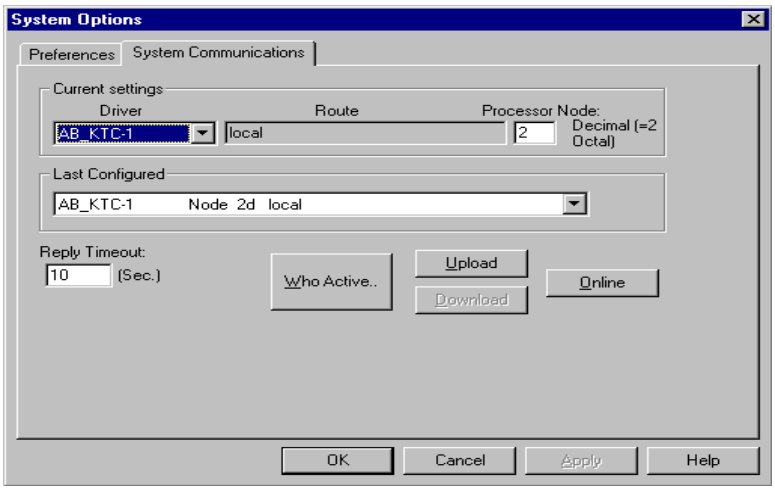
1. Launch RSNetWorx for ControlNet.
2. Check the Edits Enabled checkbox on the toolbar.
3. Right click on the second PLC-5 processor (the even node) and choose ControlNet Configuration.

   The ControlNet Configuration screen appears. (See page 8.)
4. For each entry under the Connection Type column, double click on Exclusive Owner, choose Redundant from the pull-down menu, and press Enter.
5. From the File menu, choose Save to save the ControlNet configuration.

Configure the Hot Backup Parameters

1. Launch RSLogix 5.
2. From the Comms menu, choose System Comms...

   The System Options dialog appears, with the System Communications tab selected.



3. In the Processor Node field, enter the node number of the first processor.
4. Click on the Online button to connect to the processor.
5. When prompted, click on OK to confirm that you wish to complete the upload.

   This step is required since you have made changes to the ControlNet configuration.
6. From the File menu, choose Save to save the project.
7. Click on the Hot Backup icon under the Controller folder to launch the Hot Backup Configuration utility.

   The ControlNet Hot Backup screen appears, with the Configure tab selected
8. Set the following:

   - Backup File - Enter an unused data file number. This creates a 200-word integer file to be used as the ControlNet Backup Configuration and Status file.
   - Odd Node Address - Enter the ControlNet node address corresponding to the odd node processor.
   - Send Message - Enter the message number of the Send Scheduled Message from the odd node address. (Refer to the number you recorded earlier.)
   - Receive Message - Enter the message number of the Receive Scheduled Message from the odd node address. (Refer to the number you recorded earlier.)

   If your system is properly configured, the PRI and SEC LEDs on the first processor's backup cartridge are off.

9. Save the configuration.

10. Repeat steps 1 through 9 for the second processor, saving the configuration under a different name.

    The QUAL LED on both processors should now be yellow, and you have a fully qualified backup system. If desired, you can now go to Run mode.

Advanced Configuration Options

The procedures in the previous sections outlined the steps required to configure a basic ControlNet PLC-5 backup system. In addition, there are other options you can configure for the backup system. In addition to the information provided here, you can find specific details on these features in the appendices of this manual.

- **Designated Primary** - allows you to force the processor at the odd node address to always be the primary PLC processor as long as that processor is in Run mode and is qualified.

  You can select the designated primary option from the Configuration tab of the ControlNet Hot Backup screen in RSLogix 5. Simply choose the Odd PLC Node from the Designated Primary pull-down menu.

  Note: You must make this selection for both processors, and they must be in Program mode.

- **Synchronous and Asynchronous modes** - provide you with the opportunity to choose synchronous or asynchronous program scanning for your backup system.

- **Equivalence Checking** - when enabled, equivalence checking is the performance of verification checks to ensure the qualifying secondary matches the primary. The current equivalence status of the two processors is displayed.

  Note: If Equivalence checking is enabled during qualification and differences are found, a major fault will occur.

- **Crossloading** - allows you to perform an on-demand transfer of data files from the primary to the secondary processor

- **Forced Switchover** - allows you to force the primary processor to secondary, and vice versa, on demand. This option is available while both PLC processors are in Run mode. To force a switchover, simply click on the Force Switchover button on the Configure tab of the ControlNet Hot Backup screen.

- **Status** - provides you with informational messages and parameter settings

Synchronous and Asynchronous Program Scanning

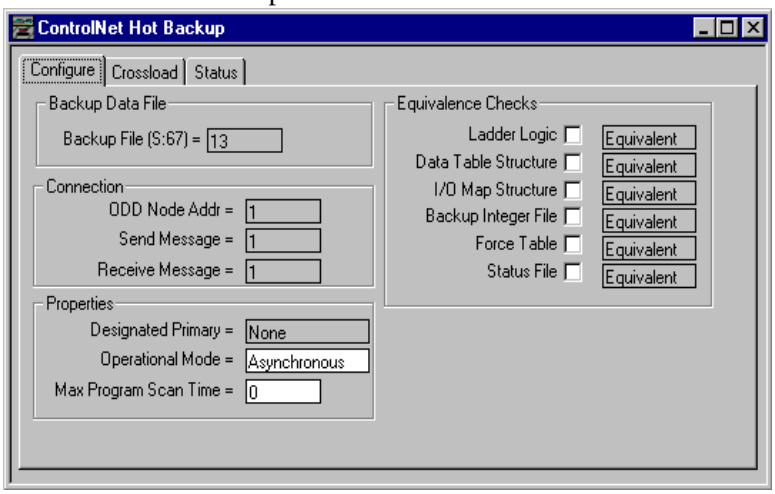
One of the most important considerations when implementing a backup system is the effect of divergence on the system. Divergence occurs when the primary and secondary controllers are running their applications and scanning the I/O asynchronously to each other. This mode of operation can cause a condition where one of the controllers is several program and I/O scans ahead of (or behind) the other. Because of this condition, the logic in each controller could resolve differently, thus creating differences (i.e., divergence) in the I/O and data tables.

As divergence between the primary and secondary controllers increases, the possibility of a bump in the process when a switchover occurs also increases. This could be critical in some backup applications.

Asynchronous program scanning allows both the primary and secondary controllers to operate as fast as they possibly can, without attempting to synchronize with each other. This mode of operation should be used when the divergence of programs, I/O tables, and data tables is not a critical consideration. Asynchronous program scanning has no effect on program scan time. You should select this mode of operation when the primary is programmed to run the normal application, and the secondary is programmed to perform a different task (e.g., a safety shutdown, a clean and wash operation, etc.).

Synchronous program scanning forces the primary and secondary controllers to synchronize their program and I/O scanning. Both controllers start their program scan at the same time, and both gather input data at the same time. This mode of operation should be used when minimizing the divergence of programs, I/O tables, and data tables is a critical and necessary consideration. Synchronous program scanning impacts program scan time in both controllers (i.e., scan times will be longer), although this impact is not significant in most cases.

You can change the operational mode from the Configure tab of the ControlNet Hot Backup screen:.



Note: When you choose Synchronous mode, you will have to enter a Maximum Program Scan Time as well. Before selecting Synchronous mode, enter a value into the Max Program Scan Time field. This value should be slightly larger than the maximum program scan time recorded in the Processor Status file. (Refer to Appendix D for more information on program synchronization.)

To change the operational mode, click on the Operational Mode box and choose the mode you would like to use. (The default mode is Asynchronous.)

Equivalence Checks

You can perform equivalence checking to verify that selected areas in both the primary and secondary PLC processors are identical.

You can enable various equivalence checks from the Configuration tab of the ControlNet Hot Backup screen. Simply check the boxes corresponding to the equivalence checks you wish to enable.

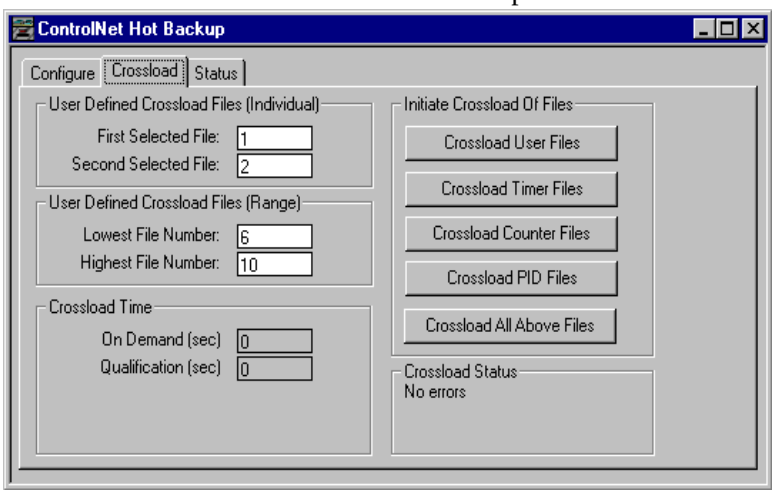
Equivalence status is updated constantly on both PLC processors while there is a qualified backup system. If there are differences between the two processors, a status message appears, indicating the difference(s), and warning you that the secondary will major fault upon switching to Run mode. The Configure tab provides you with the current status for each equivalence check; Equivalent indicates that the two processors are identical, and Different indicates that there were differences detected.

Crossloading

You can perform data table crossloading on demand. While both PLC processors are running, you can initiate a crossload from either the primary or secondary processor. You can perform a crossload on the following data file types:

- all timer accumulation values in the data table
- all counter accumulation values in the data table
- all PID files in the data table
- user-defined files, which allow you to select up to 2 separate data file numbers and/or a range of files.

You can set up and select the files to be crossloaded from the Crossload tab of the ControlNet Hot Backup screen.



To crossload timer, counter, or PID values, simply click on the respective button. The crossload is performed as soon as you click on the appropriate button.

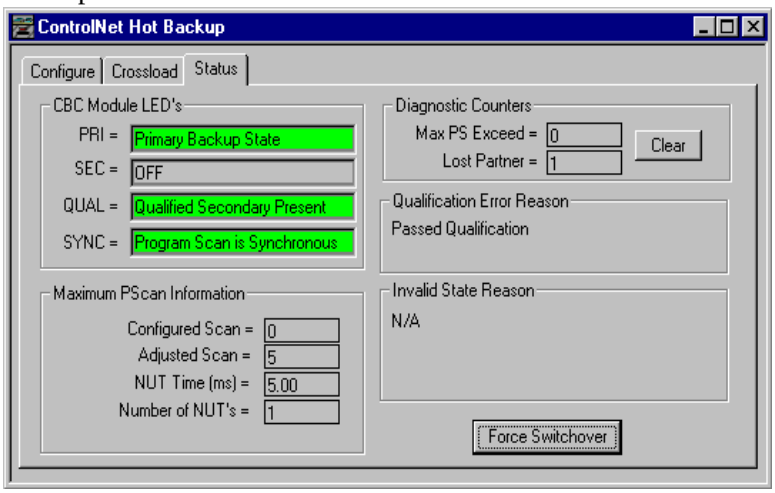
To set up user-defined crossloading, you must designate the files you wish to be crossloaded. If you are selecting individual files, enter the first file you wish to crossload in the First Selected File box. If you wish to also crossload a second file, enter it in the Second Selected File box.

If you wish to crossload a range of files, enter the lowest file number and the highest file number in the respective boxes.

Once you have selected the files you wish to crossload, click on the Crossload User Files button to perform the operation. Note that you can perform a crossload for individual files and for a range of files simultaneously.

Status

You can view system status from the Status tab of the ControlNet Hot Backup screen.



The CBC Module LEDs section mirrors the display of the LEDs on the 1785-CHBM module which is currently online.

Diagnostic Counters

Diagnostic counters provide information on the number of times the Maximum Program Scan has exceeded the Maximum Program Scan Time configured for the system when in Synchronous mode. These counters are incremented by 1 every time the actual program scan is greater than the configured program scan. The Lost Partner counter increments every time the system has detected a loss of communication between the primary and secondary PLC processors. You can press the Clear button to reset these values.

Qualification Error Reason

If the qualification of the system fails, the Qualification Error Reason indicates the reason why the failure occurred. Refer to Chapter 4 for information on corrective actions you can take.

Invalid State Reason

If the system is in an Invalid backup state (refer to Appendix B for more information on backup states), a description of the problem is displayed. Refer to chapter 4 for information on corrective actions you can take.

Maximum Pscan Information

This information is applicable for Synchronous mode operation only. The following parameters are listed in this section:

- Configured Scan - the Maximum Program Scan Time
- Adjusted Scan - the Maximum Program Scan Time rounded up to the next integer multiple of the NUT
- NUT Time (ms) - the parameter configured in RSNetWorx
- Number of NUTs - the number of NUTs in the Adjusted Maximum Program Scan Time

Processor Editing Considerations

There are some considerations you should be aware of when editing the processor of a ControlNet PLC-5 backup system. Editing, in this context, refers to any changes you make to the program files, data table structure, force tables, and status file. Edits that you make to one processor are not automatically transferred to the other processor. Thus, if you wish for edits to apply to both processors, you must take the steps to make that happen.

Most simply, you can ensure the changes are made to both processors by manually making those changes yourself. If your edits are small, this might be the fastest and easiest solution. However, if you have made large amounts of editing changes to one processor, it may be difficult and time consuming to make all the same editing changes to the other processor. This section describes another method for doing so.

Downloading Editing Changes

Downloading a program saved from one processor to another can greatly simplify the transfer of editing changes from one processor to another. If you follow the steps described earlier in this chapter, in the section entitled "Create and Download the Project for the Second PLC Processor," then you can complete this processor-to-processor download. The steps outlined there ensure that a new, different project name is created for the program that is downloaded. They also ensure that the ControlNet configuration information remains unique for each of the processors, which must be the case. This means that any edits you make to the I/O map table, you must manually make on each processor.

Testing Data Table Edits

There may be instances where edits are made to the data table structure, and these edits need to be tested on a running system. If this is the case, place one of the processors in your backup system into Program mode, and make the edits to that processor. Make sure that the data table structure and the ladder program equivalence checks are disabled while performing edit switchovers, since ladder program equivalence checks are dependent on data table structures.

Next, place the edited system into Run mode. A forced switchover can be performed, which makes the edited processor the primary, and the unedited processor the secondary. If problems occur within the edited system, a second forced switchover makes the unedited processor primary again.

Note that Qualification crossloading and on-demand crossloading are disabled when the data table structures between the processors are different.

Monitoring and Troubleshooting Your ControlNet PLC-5 Backup System

Chapter Objectives

This chapter describes the diagnostic capabilities of the ControlNet PLC-5 backup system, and provides you with tips to help you in troubleshooting difficulties with your system.

The PLC-5 ControlNet backup system generates diagnostic information to assist you with troubleshooting problems that may arise within a backup application. Most of the diagnostic information is stored within the ControlNet Backup Configuration and Status file. Other ControlNet backup diagnostic information is stored in the Major Fault Code word of the Status File (S:12), and on the LEDs of the 1785-CHBM ControlNet backup cartridge.

You can access the ControlNet Backup Configuration and Status file directly via ladder logic and the data monitor, or indirectly via the Hot Backup utility within RSLogix 5. The sections in this chapter refer only to direct access to the ControlNet Backup Configuration and Status file, though we recommend performing the same operation via the Hot Backup utility whenever possible.

ControlNet PLC-5 Backup-Specific Major Fault Error Codes

The PLC-5 processor stores major fault codes in word 12 of the processor status file (S:12). The following table lists new major fault codes specific to the ControlNet Hot Backup processor and the suggested corrective action for each.

If you see fault code:	Which indicates this fault:	Take this corrective action:
230	System attempted transition to Run mode with processor in Invalid backup state.	Change from the Invalid backup state to the No Control backup state before transitioning into Run mode. Refer to the Invalid backup state troubleshooting table later in this chapter.
231	Bypassed qualification (may occur during race condition when both processors attempt to go into Run mode at the same time).	Transition the PLC-5 processors into Run mode one at a time.
232	Both processors attempted to be primaries.	Check all media for broken cables, loose connectors, missing terminators, etc..
233	ControlNet configuration invalid on transition into Run mode.	Reconfigure the ControlNet channel.
234	Failed Qualification.	Refer to the qualification major faults troubleshooting table later in this chapter.

ATTENTION: The processor does not invoke the fault routine for any of the new fault codes for the ControlNet PLC-5 backup system since they are non-recoverable faults.

Using the 1785-CHBM Cartridge Status Indicators

The 1785-CHBM cartridge status indicators indicate the operational state of the ControlNet PLC-5 backup system. The following table lists the various LED states and the recommended action:

LED	Color	Indicates	Probable Cause	Corrective Action
PRI	Green	This processor is the primary (i.e., it controls the outputs).	Normal operation	No action required
	Green blinking	This processor is in the Lonely Primary backup state	No good scheduled connections	Check media for broken cables, loose connectors, missing terminators, etc.
	Red	The backup system is not yet completely configured (i.e., system is in the Invalid backup state).	•Improper backup configuration parameters •Improper ControlNet Backup Integer file	Refer to Troubleshooting the Invalid Backup State section, later in this chapter.
	Off	This processor is not the primary (i.e., system is in the No Control or Secondary backup state).	Normal operation	No action required
SEC	Yellow	This processor is the qualified secondary (i.e., system is in the Secondary backup state).	Normal operation	No action required
	Red	The backup system is not yet completely configured (i.e., system is in the Invalid backup state).	•Improper backup configuration parameters •Improper ControlNet Backup Integer file	Refer to Troubleshooting the Invalid Backup State section, later in this chapter.
	Off	This processor is not the secondary (i.e., system is in the No Control or Primary backup state).	Normal operation	No action required
QUAL	Green	The system has both a primary and a secondary processor, which are communicating properly with each other; the secondary processor is qualified.	Normal operation	No action required
	Yellow	The system has both a primary and a secondary processor, which are communicating properly with each other, but the secondary is not yet qualified.	Normal operation	No action required
	Alternating yellow and green	Qualification active	Normal operation	No action required
	Off	The primary and secondary processors are not communicating properly with each other.	•Standalone processor •One or both processors are in the Invalid backup state •Improper backup configuration parameters	Verify that the connection parameters (words 0 - 2) of the ControlNet Backup Integer file are the same for both processors.
SYNC	Green	The system is operating in synchronous mode, and this processor has never exceeded the adjusted maximum program scan time parameter.	Normal operation	No action required
	Red	The system is operating in synchronous mode, and this processor has been out of sync (i.e., its actual program scan time has exceeded the adjusted maximum program scan time parameter). While the out of sync condition may have been temporary, this LED remains illuminated to indicate that an out of sync condition has occurred.	•Maximum Program Scan Time configuration parameter too small •Spike in program scan time, possibly due to online editing	•Clear the Maximum Program Scan Exceeded counter by writing a non-zero value into the clear diagnostics counters word (word 32) of the ControlNet Backup Configuration and Status file. •Increase Maximum Program Scan Time configuration parameter (word 14) of the ControlNet Backup Configuration and Status file.
	Off	The system is operating in Asynchronous mode.	Normal operation	No action required

Troubleshooting the Invalid Backup State

The Invalid Backup state is indicated when both the PRI and SEC LEDs are red. The first thing to check is that you have created the ControlNet Backup Configuration and Status file and that the file number of this file is placed into the processor status file word S:67. This file must be an Integer file (file type N) and must be exactly 200 words in length.

The ControlNet Backup Configuration and Status file contains a diagnostic word (word 5) that indicates the reason for the Invalid backup state. The following table lists the various Invalid backup state reason codes and suggested corrective action.

If you see reason code:	Which indicates this condition:	Take this corrective action:
0	Valid backup state	No action required
1	Receive handshake connection not found in I/O Map Table	• Configure the handshake connections in the I/O map table. • Enter the handshake connection numbers in words 1 and 2 of the ControlNet Backup Configuration and Status file.
2	Send handshake connection not found in I/O map table	• Configure the handshake connections in the I/O map table. • Enter the handshake connection numbers in words 1 and 2 of the ControlNet Backup Configuration and Status file.
3	Receive handshake connection wrong size	Make the handshake connection in the I/O map table 5 words long.
4	Send handshake connection wrong size	Make the handshake connection in the I/O map table 5 words long.
5	Node address number wrong	Enter the odd node number of the odd-even backup pair into word 0 of the ControlNet Backup Configuration and Status file.
6	Operation mode word invalid	Enter a valid operation mode value into word 10 of the ControlNet Backup Configuration and Status file. 0 = asynchronous 1 = synchronous
7	Equivalence mode word invalid	Enter a valid equivalence mode word (i.e., 0 - 63) into word 11 of the ControlNet Backup Configuration and Status file.
8	Designated Primary word invalid	Enter a valid Designated Primary word into word 12 of the ControlNet Backup Configuration and Status file. 0 = inactive 1 = active
9	Maximum Program Scan Time word invalid	Enter a valid Maximum Program Scan Time word (i.e., less than or equal to 128*NUT) into word 13 of the ControlNet Backup Configuration and Status file.
11	Handshake Requested Packet Interval (RPI) invalid	Make the handshake connection's RPI in the I/O map table at least one NUT, but less than 2 NUTs.
12	Crossload file number parameters invalid	• Enter valid file numbers (0 - 999) into words 55 through 58 of the ControlNet Backup Configuration and Status file • Make sure the crossload range low word (word 57) value is less than or equal to the crossload range high word (word 58) value.
13	ControlNet NUT not established. Until the processor is attached to the ControlNet channel, the NUT is unknown.	Attach the processor to the ControlNet channel.

Troubleshooting Qualification Major Faults

When a qualification major fault occurs (S:12 = 234), the ControlNet Backup Configuration and Status file contains a diagnostic word (word 46) that indicates the reason why the qualification major fault occurred. The following table lists the various qualification major fault reason codes and the suggested corrective action.

If you see reason code:	Which indicates this condition:	Take this corrective action:
0	Qualification successfully completed	No action required
1	Failed Qualification Equivalence check - Ladder programs different	• Disable ladder program equivalence check, if desired. • Make ladder programs identical in each processor.
2	Failed Qualification Equivalence check - Data Table Structures different	• Disable data table structure equivalence check, if desired. • Make data table structures identical in each processor.
3	Failed Qualification Equivalence check - Redundant connections in I/O Map Tables different	• Disable Redundant Connections in I/O Map Table equivalence check, if desired. • Make redundant connections identical in each processor.
4	Failed Qualification Equivalence check - ControlNet Hot Backup file connection parameters different	• Disable ControlNet Hot Backup file connection parameters equivalence check, if desired. • Make ControlNet Hot Backup file connection parameters identical in each processor.
5	Failed Qualification Equivalence check - Force Tables different	• Disable Force Tables equivalence check, if desired. • Make Force Tables identical in each processor.
6	Failed Qualification Equivalence check - Configuration parameters in processor status file different	• Disable processor status file equivalence check, if desired • Make processor status file configuration parameters identical in each processor
8	Processor major faulted during qualification	Fix the reason for the major fault. Refer to S:12 for major fault codes
9	Keyswitch changed to Program during qualification	No action required
10	Files being created or deleted during qualification	Refrain from editing the data table file or program files during qualification.
11	Upload or Download in progress during qualification	Refrain from uploading or downloading to the processor during qualification.
12	ControlNet channel reconfiguration in progress during qualification	Refrain from performing a ControlNet channel reconfiguration during qualification.
13	The processor changed from the No Control backup state to the Invalid backup state during qualification	Refrain from modifying the ControlNet backup configuration parameters during qualification.
14	The partner processor was in the Primary backup state when qualification started. The partner processor changed out of the Primary backup state during qualification.	Clear the fault and go back into Run mode.
15	The partner's ControlNet Hot Backup configuration parameters are invalid	Refrain from changing the partner processor's ControlNet Hot Backup configuration parameters during qualification.
17	Qualification crossload failed	Refer to the Troubleshooting Qualification Crossloads section in this chapter.
18	Edits in progress during qualification	Refrain from editing during qualification.

Troubleshooting Qualification Crossloads

If the data table structures are the same between the two processors, data table crossloads automatically occur during qualification. Should the Qualification Data Table crossloads fail, the processor major faults. (Refer to Appendix C for more information on data table crossloading.)

When a data table crossload fails, diagnostic information is stored in 2 words of the ControlNet Backup Configuration and Status file. Word 54 of this file contains the file number of the crossload that failed; word 53 contains the error code indicating the reason why the crossload failed. These error codes are identical to the Message Instruction Error Codes. (See the Instruction Set Reference Manual, Publication 6200-6.4.11 for a complete listing of the various error codes which can be encountered while executing a Message Instruction.)

For example, a qualification crossload could fail if the Data Table file on the primary processor has read privileges disabled. This error shows up as error code 0xF00B (privilege error) in word 53 of the ControlNet Backup Configuration and Status file.

Note: If the file number of the crossload that failed (word 54 of the ControlNet Backup Configuration and Status file) is 0xFFFFon the qualifying processor, then the file number that failed is on the primary processor.

ControlNet Backup Configuration and Status File

The data table file number of the ControlNet Backup Configuration and Status file can be found in the PLC-5 processor at word S:67. The default configuration parameters in this file are initialized, when the file exists, the value in S:67 is correct, and at least one of the three connection parameters (i.e., one of the first three words of the file) is invalid. The ControlNet Backup Configuration and Status file consists of 200 words, as defined in the following table.

Word	Definition
0	Odd node address of the odd/even pair of node addresses for the two PLC-5 backup processors.
1	Message number of the scheduled Backup Handshake connection being sent from the processor at the Odd node address.
2	Message number of the scheduled Backup Handshake connection being sent from the processor at the Even node address.
3	Backup state of the processor. Valid values include: • 0 - Invalid • 1 - No Control • 2 - Primary • 4 - Secondary
4	Qualification state of the system. Valid values include: • 0 - No qualified secondary present • 1 - Qualified secondary present

Word	Definition
5	Reason code indicating why the processor is in the Invalid backup state. This word is constantly updated until the processor is no longer in this state. Valid values include: • 0 - In valid state • 1 - Receive handshake connection not found in I/O map table • 2 - Send handshake connection not found in I/O map table • 3 - Receive handshake connection wrong size • 4 - Send handshake connection wrong size • 5 - node address number wrong • 6 - Operation mode word invalid • 7 - Equivalence mode word invalid • 8 - Designated Primary word invalid • 9 - Max Program Scan Time word invalid • 11 - Handshake is not 1 NUT • 12 - Crossload parameters invalid • 13 - NUT not established
6	This is a checksum of the first 3 words of this file. If the checksum is not valid, the firmware will continuously write default values for the configuration parameters in this file.
7	Partner present. This word is constantly updated by the PLC-5 processor, indicating whether a partner processor is handshaking with the current processor. This word is updated only when the processor is in a valid backup state (i.e., No Control, Secondary, or Primary). Valid values include: • 0 - No partner found • 1 - Partner PLC-5 handshaking with this PLC-5
8	Output Ownership Invalid Count word. This word indicates how many connections are not owned by this processor (Primary backup state only). This value is -1 when the processor is in the Secondary backup state.
9	Lonely Primary Backup State Counter. This counter is incremented every time this processor goes into the Lonely Primary backup state.
10	Operational mode of the system. Valid values include: • 0 - Asynchronous (default) • 1 - Synchronous
11	Equivalence checks; there are 6 bits defined (i.e., one bit per equivalence check). If a bit is set, the corresponding equivalence check will be performed. If the bit is not set, no check is performed. By default, all equivalence checking is enabled. The remaining 10 bits in the word must be set to 0. • Bit 0 - Ladder Logic equivalence check • Bit 1 - Data Table Structure equivalence check • Bit 2 - I/O Map Table equivalence check • Bit 3 - Backup Configuration and Status file equivalence check • Bit 4 - Force Table equivalence check • Bit 5 - Status file equivalence check
12	Designated Primary. Valid values are: • 0 - No Designated Primary (default) • 1 - The PLC-5 processor with the odd node address is the Designated Primary
13	Qualification Delay. This is the amount of time (in ms) to delay the secondary in Run mode before becoming qualified. The default value is 0.
14	Maximum Program Scan Time (Synchronous mode only); the amount of time (in ms) for the largest program scan. This value cannot be greater than 127 times the NUT value.

Word	Definition
15-19	reserved
20-24	These words are functionally the same as words 10 through 14. The difference is that words 20 through 24 display the current internal PLC-5 processor state of these configuration parameters. When in Run mode, the PLC-5 processor will continuously update words 20 through 24. In other words, the software tool will write the configuration parameters into words 10 through 14, while the PLC-5 processor will write its internal PLC-5 processor state of these configuration parameters into words 20 through 24. When you accept configuration changes, the configuration parameters in words 10 through 14 are copied into words 20 through 24.
25	Adjusted Maximum Program Scan Time. This word is the Maximum Program Scan Time parameter, rounded up to the next integer multiple of the NUT value. This word is written by the PLC-5 processor, and is continuously updated while the processor is in Run mode.
26	The number of NUTs per Maximum Program Scan Time. This word is the number of NUTs in the Adjusted Maximum Program Scan Time. This word is written by the PLC-5 processor, and is continuously updated while the processor is in Run mode.
27	The NUT time, in 10 microsecond units, is continuously written here while the processor is in Run mode.
28	Configuration status. This word gives either the reason why the configuration attempt was unsuccessful, or whether the configuration parameters were overwritten because the system went into Run mode as a secondary system. • 6 - Operation mode word invalid • 7 - Equivalence Check word invalid • 8 - Designated Primary word invalid • 9 - Max Program Scan Time word invalid • 10 - Configuration parameters were overwritten by the primary system • 12 - Crossload parameter invalid
29	reserved
30	Accept Configuration Changes. A non-zero value written into this location forces the primary PLC-5 processor to accept the new configuration parameters. After the PLC-5 processor has done so, it will zero this word. This command is only in effect for the primary processor. The configuration parameters you change are: • Operational mode • Maximum Program scan time • Equivalence checks • Designated primary • Crossload parameters
31	Force Switchover. A non-zero value written into this location forces the primary processor to switch over control to a secondary processor. After the processor has read the non-zero value, the PLC-5 processor will zero this word. This command works for both the primary and secondary processors. However, if there is a Designated Primary, this command will not function.
32	Clear Diagnostic Counters. A non-zero value written into this location clears the maximum program scan exceed counter, the lost partner counter, and the lonely primary backup state counter. After the processor has read the non-zero value, it will clear this word. This feature works for both the primary and secondary processors, but will only work in Run mode.

Word	Definition
33	Perform On-Demand Crossload. You can specify whether to crossload timers, counters, PID files, or user-defined files (configured in words 55, 56, 57, and 58 of the ControlNet Backup Configuration and Status file) by setting appropriate bits in this word. After the PLC-5 has read the word, it clears it. This feature works for both primary and secondary processors. • Bit 0 - Crossload Timers • Bit 1 - Crossload Counters • Bit 2 - Crossload PID • Bit 3 - Crossload user-defined files
34-39	reserved
40-45	The timedate stamp indicating when the processor last took over as the primary is stored here. The format of the data is the same as the clock in the status file.
46	Qualification status. The reason code for why the processor failed qualification or if the configuration parameters were changed by the primary. Valid values include: • 0 - Passed qualification • 1 - Equivalence check - Ladder programs different • 2 - Equivalence check - Data table structures different • 3 - Equivalence check - I/O map tables different • 4 - Equivalence check - ControlNet Backup Configuration and Status files different • 5 - Equivalence check - Force tables different • 6 - Equivalence check - Status files different • 7 - Qualification passed, but configuration parameters changed by primary • 8 - Qualification failed due to processor being faulted • 9 - Qualification failed due to keyswitch change to Program mode • 10 - Qualification failed due to Run mode inhibited • 11 - Qualification failed due to processor uploading or downloading program • 12 - Qualification failed due to ContronNet reconfiguration in progress • 13 - Qualification failed due to invalid backup state • 14 - Qualification failed due to partner no longer being a primary • 15 - Qualification failed due to invalid backup configuration parameters • 16 - unused • 17 - Qualification crossload failed • 18 - Qualification failed due to unavailable edit resource
47	Lost Partner Counter. A counter which increments every time you lose communication with the partner processor.
48	Maximum Program Scan Exceed Counter. A counter which increments every time the maximum program scan time is exceeded. This counter is reset for the processor on transition into Run mode.
49	Equivalence Check Error. A bit is set for each area in which an equivalence mismatch is detected. There is a background check of the ladder program, force tables, and status files for differences. • Bit 0 - Set if the ladder programs between the two systems are different • Bit 1 - Set if the data table structures between the two systems are different. Note the data table structure is not the same as the values in the data table files. • Bit 2 - Set if the I/O map tables between the two systems are different • Bit 3 - Set if the Backup Configuration and Status files between the two systems are different • Bit 4 - Set if the Force tables between the two systems are different • Bit 5 - Set if the Status files between the two systems are different

Word	Definition
50	Qualification Crossload Time. The time (in ms) it takes to crossload the entire data table from the primary processor to the secondary processor. This value is overwritten each time the processor goes through qualification.
51	On-Demand Crossload Time. The time (in ms) it takes to crossload the data table state information from the primary to the secondary. This value is overwritten each time the processor goes through qualification, and when you initiate an On-Demand Data Table Crossload command.
52	Crossload Active. This word equals 1 when a crossload is active; it is equal to 0 when a crossload is not active. This word applies to both Qualification and On-Demand crossloads.
53	Crossload Status. This is a Message instruction error code. The processor writes the value into this word. For information on error descriptions, refer to your PLC-5 Instruction Set Reference Manual.
54	Crossload Failed File. This word displays the file number on which the crossload failed. The crossload status word located in word 53 displays the error code and word 54 displays its correlated file.
55	User-Defined Crossload File 1. You can select a single file number, written in this word, to be crossloaded during the Qualification crossload, and on-demand when setting the appropriate bit in word 33.
56	User-Defined Crossload File 2. You can select a single file number, written in this word, to be crossloaded during the Qualification crossload, and on-demand when setting the appropriate bit in word 33.
57	User-Defined Crossload Range Low File. You can select a range of files to be crossloaded during the Qualification crossload, and on demand when setting the appropriate bit in word 33. The lower file number of the range of files to be crossloaded must be written into this register.
58	User-Defined Crossload Range High File. You can select a range of files to be crossloaded during the Qualification crossload, and on demand when setting the appropriate bit in word 33. The higher file number of the range of files to be crossloaded must be written into this register.
59-64	The secondary time/date stamp of when the processor last took over as secondary processor. The format of the date is the same as the system clock in the status file.
65-68	These words are functionally the same as words 55 through 58. The difference is that these words display the current PLC-5 processor state of these configuration parameters. When in Run mode, the processor continuously updates words 65 through 68. In other words, new configuration parameters are written into words 55 through 58, while the PLC-5 processor writes its internal state of these configuration parameters into words 65 through 68. When you accept a configuration, the configuration parameters in words 55 through 58 are copied into words 65 through 68.
69-199	reserved

Important: Do not alter any reserved words. Values in these words may be changed or used by the PLC-5 processor during normal operation.

Specifications

Specifications

The following specifications are for the 1785-CHBM cartridge.

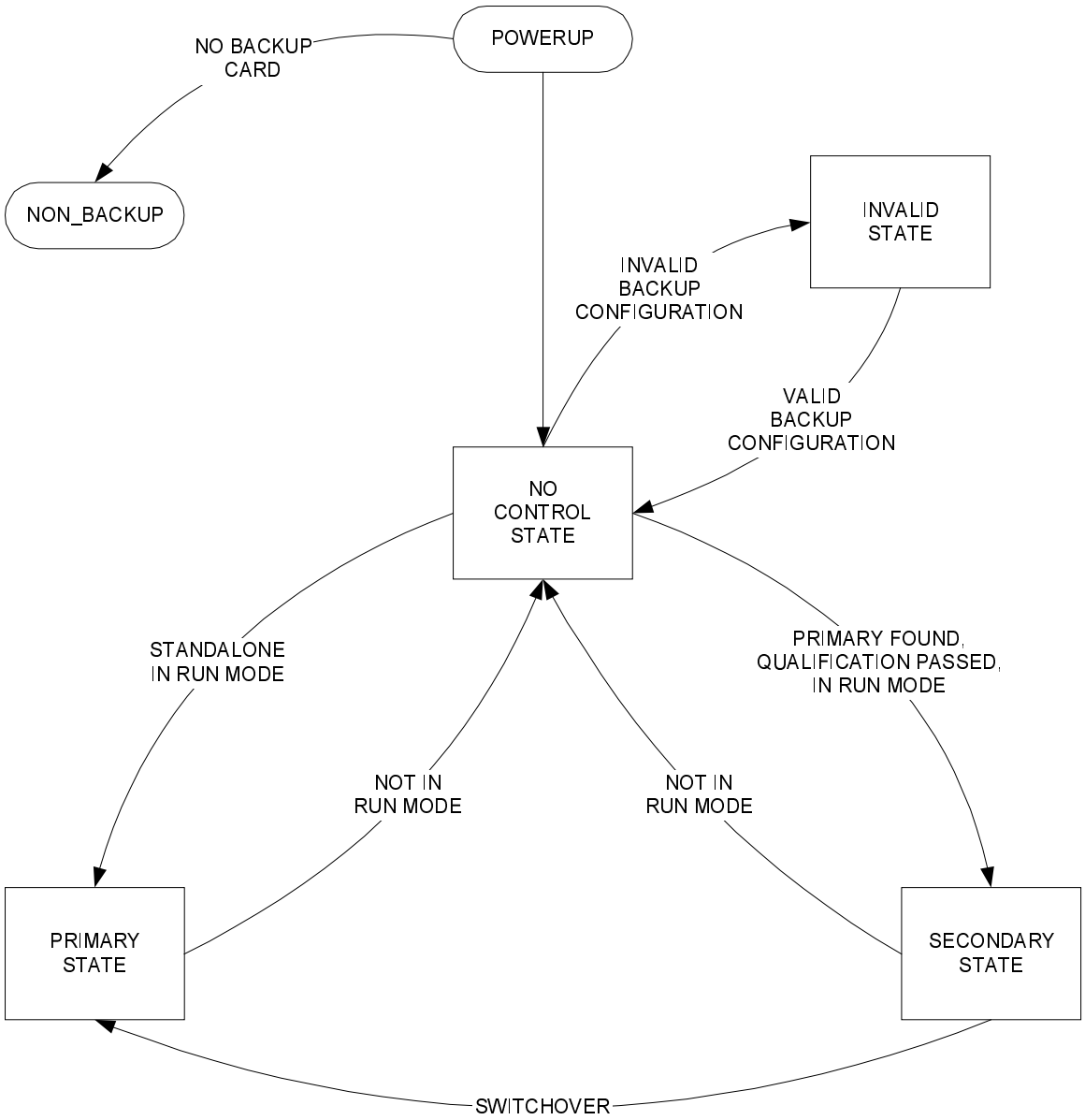
Description:		Value:
Memory Module		1785-CHBM
Capacity		100K words
Type		Nonvolatile
Write Protection		By removing the jumper
Weight		70.875g 2.5 oz.
Environment	Operating Temperature	0° to 60° C (32° to 140° F)
	Storage Temperature	-40° to 85° C (-40° to 185° F)
	Relative Humidity	5% to 95% (without condensation)
Shock Testing	Operating	15 g peak acceleration at 11 ms duration
	Non-operating	3 g peak acceleration at 11 ms duration
Vibration Testing		2 g peak acceleration at 10-500 Hz
Agency Certification		• CSA certified • CSA Class I, Division 2 Groups A, B, C, D • UL listed • CE marked for all applicable directives

Backup States

Chapter Objectives

This Appendix describes the possible backup states and backup state transitions of the PLC-5 ControlNet backup system. There are four main backup states:

- Invalid
- No Control
- Primary (and Lonely Primary)
- Secondary



BACKUP STATE DIAGRAM

Invalid Backup State

When an improper backup configuration exists, the PLC-5 ControlNet backup system goes into the Invalid backup state. Both the Primary and Secondary LEDs on the 1785-CHBM cartridge are solid red when the system is in this state, and the Qualified and Synchronous LEDs are off. If you switch the system to Run mode while in the Invalid backup state, a major fault occurs. (Refer to Chapter 4 for definitions of the major fault codes.)

The backup system enters the Invalid backup state when one or more of these conditions exists:

- the 200-word ControlNet Backup Configuration and Status File does not exist
- the ControlNet Backup Configuration and Status File exists, but is the wrong size (this file must be exactly 200 words in length)
- the file number index to the ControlNet Backup Configuration and Status File in S:67 is incorrect
- the ControlNet peer-to-peer backup connections, configured in RSNetWorx, do not exist or are not correct; these connections must:
  - be sent to and received from the partner processor
  - be 5 words long
  - have an actual packet interval rate equal to one NUT
- the first 3 words of the ControlNet Backup Configuration and Status File are incorrectly configured

Word	Valid Configuration
0	must equal the odd node number of the odd-even PLC-5 processor pair
1	must equal the message number of the ControlNet scheduled peer-to-peer backup connection going from the odd node number to the even node number of the odd-even PLC-5 processor pair
2	must equal the message number of the ControlNet scheduled peer-to-peer backup connection going from the even node number to the odd node number of the odd-even PLC-5 processor pair

- one of the optional configuration parameters in the ControlNet Backup Configuration and Status File is invalid; the following optional parameters are checked:
  - Operational mode (invalid if not equal to 0 or 1)
  - Equivalence checks (invalid if greater than 0x3f)
  - Designated primary (invalid if not equal to 0 or 1)
  - Maximum program scan time (invalid if greater than (128 x NUT) and synchronous operational mode)
  - Crossload File 1, Crossload File 2, Crossload File Low, and Crossload File High (invalid if greater than or equal to 1000)

While in the Invalid backup state, you can set default parameters for the optional configuration parameters by intentionally entering an incorrect configuration value for one of the first 3 words in the ControlNet Backup Configuration and Status File. This will force all parameters to be set to their default values. For example, by setting Word 0 to be equal to 0, the following optional configuration parameters are defaulted:

- Operational Mode = Asynchronous Mode
- Equivalence Checks = All Disabled
- Designated Primary = Disabled
- Maximum Program Scan Time = 0
- Qualification Delay = 0
- Crossload File 1 = 0
- Crossload File 2 = 0
- Crossload File Low = 0
- Crossload File High = 0

No Control Backup State

When a valid backup configuration exists, but the PLC-5 processor is not in Run mode, the PLC-5 ControlNet backup system is in the No Control backup state. Both the Primary and Secondary LED's on the 1785-CHBM cartridge are off when in this state. While in the No Control backup state, you can switch the PLC-5 processor to Run mode; once in Run mode, however, the processor is no longer in this state.

If there is a valid partner PLC-5 ControlNet backup system, and the systems are connected on the ControlNet channel, the Qualified LED is solid yellow. This indicates that the necessary configuration needed to allow the backup pair to successfully communicate with each other has been achieved.

You can make any configuration changes you wish to the ControlNet Backup Configuration and Status file while the PLC-5 processor is in the No Control backup state. Note that placing an invalid parameter into the ControlNet Backup Configuration and Status file causes the processor to switch to the Invalid backup state.

Primary Backup State

When a PLC-5 ControlNet backup system is in Run mode, and is actively controlling all of the system outputs, it is in the Primary backup state. The Primary LED is green, either blinking or solid; the Secondary LED is off. The PLC-5 processor can go out of Primary backup state if either the PLC-5 system is switched out of Run mode or the partner PLC-5 becomes the Primary.

If there is a valid partner PLC-5 ControlNet backup system, and the systems are connected on the ControlNet channel, the Qualified LED is on. If the Qualified LED is solid yellow, the partner PLC-5 is not a qualified secondary system, however the two systems **are** properly configured to communicate with each other. If the Qualified LED is solid green, the partner PLC-5 is a qualified secondary and could take control of the system outputs if necessary. If the Qualified LED is off, then there is no partner PLC-5 system communicating with this PLC-5 system on the ControlNet channel.

When the PLC-5 is in the Primary backup state, you can no longer force the backup system to be in the Invalid backup state through configuration changes. All configuration changes are checked for validity before being accepted.

Note: If a newly-entered configuration parameter is invalid, the backup system uses the previous configuration values.

Lonely Primary Backup State

The Primary LED is solid green if there is at least one good scheduled connection on the ControlNet channel. If there are no good scheduled connections on the ControlNet channel the Primary LED blinks green. This is referred to as the Lonely Primary backup state. Since there are no valid scheduled connections on the ControlNet channel, this PLC-5 is not controlling the system outputs on the ControlNet channel. A system could go into Lonely Primary backup state, for example, when the ControlNet cable is disconnected.

When in Lonely Primary backup state, the PLC-5 waits 10 seconds after the first connection is established before actively controlling the system outputs on the ControlNet channel. This is so that if an existing partner PLC-5 is controlling the system outputs on the ControlNet channel, the PLC-5 system in Lonely Primary backup state does not take control of the system outputs from the partner. If, during the 10-second wait, the PLC-5 in Lonely Primary backup state establishes communication with the partner PLC-5 and notices that the other PLC-5 is a primary, the PLC-5 in the Lonely Primary backup state major faults. (Refer to chapter 4 for description of specific major fault codes.)

Secondary Backup State

When a PLC-5 ControlNet backup system is in Run mode, and is not actively controlling the system outputs, it is in the Secondary backup state. The Secondary LED is solid yellow, the Primary LED is off, and the Qualified LED is solid green. The PLC-5 can go out of Secondary backup state if either the PLC-5 system goes out of Run mode, or the partner PLC-5 system is no longer the primary. If the partner PLC-5 is no longer the primary, the PLC-5 in the Secondary backup state becomes the primary and assumes control of the system outputs.

When the PLC-5 is in the Secondary backup state, you cannot make any backup configuration changes to that PLC-5 system. All backup configuration changes must be made to the primary system and those changes are immediately passed on to the secondary system.

Backup State Transitions

In the previous section, we described the possible states of the PLC-5 ControlNet backup system, with references to transitions between states. For example, when in the No Control backup state, if you change a configuration parameter to an invalid value, the PLC-5 ControlNet backup system transitions into the Invalid backup state.

This section describes two backup state transitions: Qualification and Switchover.

Qualification

Qualification occurs when the PLC-5 ControlNet backup system transitions from the No Control backup state to either the Secondary backup state or the Primary backup state. You activate this backup state transition by changing the PLC-5 system from Program mode to Run mode.

You can tell that a qualification is active when the Qualified LED blinks yellow and green, alternately.

Qualification: From the No Control State to the Primary State

The backup state transition from No Control backup state to the Primary backup state occurs when the PLC-5 system transitions from Program mode to Run mode and

- there is no partner PLC-5 system, OR
- the partner PLC-5 system is not in Primary backup state, OR
- the partner PLC-5 system is not communicating with this PLC-5 processor

The transition from No Control backup state to Primary backup state is simple. There are no checks to be done. The transition occurs immediately if there is no Qualification Connection Delay. Once the transition to the Primary Backup State is complete, the LED's on the 1785-CHBM cartridge indicate the new backup state.

Qualification: From the No Control State to the Secondary State

The backup state transition from No Control backup state to Secondary backup state occurs when the PLC-5 system transitions from Program mode to Run mode, and the partner PLC-5 processor is in the Primary backup state and is communicating with this PLC-5 processor. The entire qualification process has many components:

- Connection delay

  There may be up to a 10-second delay before qualification begins because of the time needed to establish connections on the ControlNet channel. It is important to make a connection to the partner PLC-5 processor in order to determine if this processor is to become primary or secondary. If the partner PLC-5 processor is primary, this processor goes through qualification to become a secondary system. If the partner PLC-5 processor is not the primary, or if a partner is not on the ControlNet channel, this processor goes through qualification to become primary. In most cases there is no qualification connection delay.

  There are, however, two cases where the PLC-5 system waits 10 seconds before starting qualification. The first case is when a reconfiguration of the ControlNet channel occurs. When this occurs, all connections are terminated and must be reestablished; the 10-second wait allows the connection to be reestablished with the partner PLC-5 processor. Note that at powerup, a ControlNet channel reconfiguration occurs.

  The second case in which the PLC-5 system waits 10 seconds before starting qualification is when the first connection is established on the ControlNet channel. This is indicated when the ControlNet I/O LED changes from red to green. This could occur, for example, when a disconnected cable gets reattached. There is no visual indication when a qualification connection delay is active.

- Backup configuration parameters passed to qualifying system

  After the qualifying PLC-5 system has waited, if necessary, for the qualification connection delay, the backup configuration parameters are passed from the primary PLC-5 system to the qualifying PLC-5 system. The backup configuration parameters which were originally in the qualifying system are overwritten and lost. The backup configuration parameters that are passed from the primary system and overwritten on the qualifying system are:

  - Operational Mode
  - Equivalence Checks
  - Designated Primary
  - Maximum Program Scan Time
  - Crossload File 1
  - Crossload File 2
  - Crossload File Low
  - Crossload File High

- Equivalence checks

  The PLC-5 ControlNet backup system does not download the entire memory from the primary system to the secondary system; there are certain data table values that are crossloaded. Areas such as the program files and data table structures may be different between the primary and secondary system. In some applications, this is desirable. However, in most applications, you must know for certain whether the primary and secondary systems are identical, or whether they may differ in certain areas. Equivalence checking gives you the option of enforcing a qualification major fault if the systems differ. (Refer to Chapter 4 for descriptions of specific major faults.)

  You can implement qualification equivalence checking by calculating checksums for different memory areas of the PLC-5 system. These checksums are calculated on both the primary and qualifying secondary system, and are passed from the primary system to the qualifying system before equivalence checking is performed. If you enable configuration checking for a particular area, and the primary checksum is different than the qualifying checksum, qualification fails and the qualifying system declares a major fault.

  There are 6 different areas in which equivalence checking can be performed:

  - Program File Structure and Program Files - This checksum is calculated for all the Program files, with the notable exception of SFC files. This checksum continues to be calculated when the backup system is qualified. This allows status to be available regarding whether the Program file checksums differ for a qualified backup system.

  - Data Table Structure - This checksum is only calculated when the PLC-5 system goes through qualification. Since the Data Table structure cannot change when in Run mode, this checksum does not change after qualification. The Data Table Structure checksum includes the data table file number, the data table file type, and the size of the data table file. The Data Table Structure checksum does not include the data table file privilege information or the values of the data table file elements.

  - ControlNet I/O Map Table - This checksum is only calculated when the PLC-5 system goes through qualification. Since the ControlNet I/O map table cannot change when the PLC-5 system is in Run mode, this checksum does not change after qualification. The ControlNet I/O Map Table checksum only includes the scheduled redundant connections. Thus, as long as the scheduled redundant connections are the same between the backup PLC-5 systems, the ControlNet I/O Map Table checksums will match.

- ControlNet Backup Configuration and Status file - This checksum is only calculated when the PLC-5 system goes through qualification. Since this checksum cannot change when the PLC-5 system is in Run mode, this checksum does not change after qualification. The ControlNet Backup Configuration and Status File checksum is only calculated on the first 3 words of the ControlNet Backup Configuration and Status File.

- Force Tables - This checksum is calculated for all I/O force tables and for force control words, and continues to be calculated when the backup system is qualified. This allows status to be available regarding whether the Force Table checksums differ for a qualified backup system. Included in the Force Tables checksum are:

  • I/O Force Table values
  • Extended Force Table values
  • Force Status (is forcing enabled and are forces present)

  No SFC information is included in the Force Tables checksum. Also, note that you cannot perform forcing on DIF or DOF files.

- Status File - This checksum is calculated for various configured words in the Status File, and continues to be calculated when the backup system is qualified. This allows status to be available regarding whether the Status File checksums differ for a qualified backup system. The different words included in the Status File checksum for equivalence checking are:

  • Watchdog Set Point
  • Fault Routine Number
  • STI Set Point
  • STI Routine Number
  • I/O RESET Bits
  • I/O INHIBIT Bits
  • PII Routine Number
  • PII Word Number
  • PII AND Mask
  • PII Polarity Mask
  • PII Counter Preset
  • Data Table Protection File Number
  • ControlNet Backup Configuration and Status File Number
  • ControlNet PLC-2 File Number
  • MCP I/O Disable Word
  • MCP INHIBIT Word
  • MCP File Numbers

You can selectively enable equivalence checking for none, some, or all of the 6 of the equivalence check areas, with one exception: the Program File Structure and Program File checksum is dependent on the Data Table Structure. Thus, if you select the Program File Structure and Program File equivalence check, you should also select the Data Table Structure equivalence check.

Equivalence checking is only performed during qualification. Once a PLC-5 system passes qualification, it does not become disqualified even if the checksums for an area are different and the equivalence checking for that area is enabled. For example, if the Program File Structure and Program File equivalence check is enabled and there is a qualified secondary, you can edit the program files on either system without causing the secondary system to disqualify. However, if one of the PLC-5 systems goes out of Run mode and back into Run mode and a qualification occurs, an equivalence check failure during qualification causes a major fault to be declared for the qualifying system. Therefore, when performing edits on either PLC, we recommend that you disable equivalence checking first to avoid the condition where a PLC-5 processor cannot become qualified due to failing an equivalence check. Once all the edits are tested and placed into both PLC-5 systems, you can reenable the equivalence check.

Word 49 in the ControlNet Backup Configuration and Status file gives you equivalence check status for a qualified backup system. A bit is set for each equivalence check area if the equivalence areas checksum differs between the two processors. This word is updated every few seconds so that you can know, if secondary qualification were to happen, which equivalence checks would pass, and which equivalence checks would fail.

- Complete data table crossload

  If all the equivalence checks pass, a Qualification Data Table crossload is performed. This crossload reads the data table file values from the primary system and writes those values into the corresponding data table files in the secondary system.

  This data table crossload is performed while the qualifying PLC-5 system is still in Program mode. It is necessary to remain in Program mode until the data table crossload is finished in order to prevent the qualifying system from major faulting or going into an odd state due to uninitialized data table values. It is safer for the qualifying PLC-5 system to first do the Data Table crossload and then to go into Run mode. In that case, the data table values are close to the values on the currently executing primary system.

  Note: The time it takes to do the Qualification Data Table crossload primarily depends on the amount of data table data to be crossloaded.

All elements of all data table files are crossloaded in the Qualification Data Table crossload, with the exception of the following files. These files cannot be crossloaded because they contain processor-specific configuration and status information.

- Status File
- ControlNet Backup Configuration and Status File
- ControlNet Data Input File (DIF)
- ControlNet Data Output File (DOF)
- ControlNet Configuration File
- ControlNet I/O Status File
- ControlNet Diagnostic File

Though the complete Status File is not crossloaded, there are six words in this file that are transferred from the primary system to the qualifying system. These six words are the real-time clock.

The Qualification Data Table crossload does not occur if the Data Table Structures are not the same. If you want to ensure that a Qualification Data Table crossload occurs, you must enable equivalence checking for the Data Table structure area.

If, for some reason, the Qualification Data Table crossload fails, qualification also fails and a major fault is declared for the qualifying system. (Refer to Chapter 4 for descriptions of specific major fault codes.)

- Transition to Run mode

  Once the complete Data Table crossload is complete, the qualifying PLC-5 system transitions into Run mode. Although the PLC-5 system is now in Run mode, the PLC-5 processor is not through with qualification and is still in the No Control backup state. Also note that any outputs in the qualifying processor that are not ControlNet redundant connections are now controlled by the PLC-5 processor. This includes any local resident chassis outputs, remote I/O channel outputs, and non-redundant I/O connections on the ControlNet channel.

- State data table crossload

  Even though a Qualification Data Table crossload has occurred, some of the crossloaded data may have become stale. For example, if the Qualification Data Table crossload takes 10 seconds, the data in the original data table file that was transferred is 10 seconds old. In order to bring certain state information in the data table up to date, a Qualification State Data Table crossload is performed.

The Qualification State Data Table crossload reads data table values from the primary PLC-5 system and writes these values to the qualifying PLC-5 system. The State Data Table crossload only crossloads specific parts of the data table. There are 4 different parts of the data table that are crossloaded:

- Timer Accumulators
- Counter Accumulators
- PD elements
- User-selectable files

It may take many seconds for the Qualification State Data Table crossload to finish. The time it takes to complete the data table crossload primarily depends on the amount of data table data to be crossloaded.

Even though the State Data Table crossload may take many seconds to complete, the data that is transferred from the primary system to the qualifying system is fresh. In other words, the crossloaded data is not sitting in a buffer getting stale, waiting for all the data to be crossloaded. Each packet of data is immediately written into the qualifying system's data table. So, no matter how long the Qualification State Data Table crossload takes, the data table elements which are crossloaded into the qualifying system closely match the values in the primary system.

The Qualification State Data Table crossload does not occur if the Data Table Structures are not the same. If you want to ensure that a Qualification State Data Table crossload occurs, you must enable equivalence checking for the Data Table structure area.

If, for some reason, the State Data Table crossload fails, qualification also fails and a major fault is declared for the qualifying system.

- Transition to Secondary backup state

  After the State Data Table crossload is successfully completed, the secondary system transitions into the Secondary backup state, and qualification is complete. The LED's on the 1785-CHBM cartridge indicate the new backup state. Also, the Qualified LED on the primary system turns solid green, indicating that there is a qualified secondary system.

  If you selected the Designated Primary feature, and the odd node of the odd-even backup pair has just gone through secondary qualification, a switchover automatically occurs. The odd node becomes the primary system, and the even node transitions from the primary system to the secondary system. The even node's transition from primary to secondary happens immediately. The even node does not go through qualification when it becomes the secondary system.

Reasons for Qualification Major Fault

While qualification should complete without any problems, there are several checks performed during qualification that can cause it to fail. When the qualification procedure fails, a major fault is declared. Qualification could fail under any of the following circumstances or conditions:

- Failure of the Qualification Data Table crossload
- Failure of the Qualification State Data Table crossload
- Failure of the Equivalence Check
- The occurrence of an unrelated major fault in the PLC-5 system during qualification
- Movement of the keyswitch to Program mode during qualification
- Inability to retrieve the Edit Resource at the beginning of qualification
- Presence of one or more invalid backup configuration parameters
- A change in the primary status of the partner PLC-5 processor (i.e., either the partner PLC-5 processor became primary during qualification, or the partner PLC-5 went from primary to non-primary during qualification).
- The ControlNet backup state was Invalid backup state.

Refer to Chapter 4 (Troubleshooting) for information on fixing a Qualification major fault.

Switchover

Switchover occurs when one of the processors of the PLC-5 ControlNet backup system transitions from the Secondary backup state to the Primary backup state. The new primary processor gains control of the system outputs on the ControlNet channel; the old primary processor loses control. There are two categories for switchovers:

- Qualified Switchovers
- Unqualified Switchovers

Qualified Switchovers

Qualified Switchovers are switchovers that transition the primary processor to the Secondary backup state and the secondary processor to the Primary backup state. Thus after a Qualified Switchover, there is still a qualified backup system. There are 2 Qualified Switchover cases:

- Designated Primary

  When you configure the PLC-5 ControlNet backup system and enable the Designated Primary feature, the odd ControlNet node of the odd-even ControlNet pair is always the primary processor if the odd node has passed qualification. This feature is useful when you want a particular processor to always be the primary, whenever that processor is available.

If the even ControlNet node is the only processor to pass qualification, it is the primary processor. However, should the odd ControlNet node pass qualification, a switchover immediately occurs, the odd ControlNet node becomes the primary processor, and the even ControlNet node becomes the secondary processor.

Once there is a qualified primary processor, you cannot change (i.e., enable or disable) the Designated Primary feature. The first processor that goes through qualification determined whether the Designated Primary feature is enabled or disabled. The second processor that goes through qualification inherits the configuration setting from the first processor. In order to enable or disable the Designated Primary feature for a PLC-5 ControlNet backup system, both processors must be in Program mode. You can then change the Designated Primary feature on one of the processors. You should then qualify the processor on which you have changed this feature.

- Forced Switchover

  Forced Switchover allows you to switch over a qualified PLC-5 ControlNet backup system at any time. You activate a Forced Switchover by writing a non-zero value into the Forced Switchover word (word 31) of the Backup Integer File. Once the Forced Switchover is activated, the processor writes a zero into the Forced Switchover word of the Backup Integer File. You can activate this switchover from either the primary or secondary processor.

  Forced Switchover is useful when you want to test edits you have made in your application program. In this case, you make edits to the secondary system, force a switchover, and monitor the results of the edits. If the edits cause problems, you can perform another Forced Switchover to give the original processor control of the system outputs on the ControlNet channel.

  Since the Forced Switchover feature is activated from writing to the Backup Integer File, you can activate Forced Switchovers from external applications writing to the Backup Integer File, as well as the application on the processor itself.

  Forced Switchover does not activate for an unqualified PLC-5 ControlNet backup system or for a PLC-5 ControlNet backup system in which the Designated Primary feature is enabled.

Unqualified Switchovers

Unqualified Switchovers occur when the primary processor of a qualified PLC-5 ControlNet backup system is no longer in Run mode, or when the secondary processor loses its peer-to-peer handshake connection with the primary processor. The secondary processor then does a switchover to become a stand-alone primary processor.

There are many reasons why an Unqualified Switchover can occur:

- you changed the primary PLC-5 system out of Run mode
- a major fault occurred on the primary PLC-5 system
- the primary PLC-5 system failed
- the primary PLC-5 system lost power
- problems with the ControlNet network caused the loss of the handshake connection with the primary processor

Switchover Considerations

Switchovers do not occur without some potential problems:

- Divergence - when the data table values diverge between the primary processor and secondary processor.

  If the output values in the data tables are different between the primary and secondary systems, there will be a bump in the outputs when the new primary processor takes control of the outputs. There are features in the PLC-5 ControlNet backup system which minimize the divergence of outputs between the primary and secondary processors. These features are synchronized program scans and data table crossloads.

- Switchover time - the time delay before the new primary processor can control the system outputs on the ControlNet channel.

  There is a time period between when the old primary processor has relinquished control of the system outputs on the ControlNet channel and the new primary processor writes new system outputs on the ControlNet channel. This time period is called Switchover Time. There are two separate cases to consider: (Note that the Switchover Times described below are the worst case times. Actual Switchover Times may be smaller.)

  - Communicated Switchover - when the processor indicates to the secondary processor that a switchover must occur. The following events can cause a Communicated Switchover:

    - A Designated Primary switchover
    - A Forced switchover
    - Switching the primary PLC-5 system out of Run mode
    - The occurrence of a major fault on the primary PLC-5 system

Since the peer-to-peer handshake connection is one NUT, it only takes up to one NUT for the primary system to indicate to the secondary system that a switchover must occur. There is up to 5ms of processing on each processor to get the switchover indication from the primary system to the secondary system. Thus the formula for the Communicated Switchover Time is:

Communicated Switchover Time = 10ms + NUT

So, if the NUT is 5ms, the Communicated Switchover Time is equal to 10ms plus 5ms, or 15ms.

- Timeout Switchover - when the secondary processor loses communication with the primary processor for a certain length of time, it times out the primary processor, and then performs a switchover. The following events can cause a Timeout Switchover:
  - Primary PLC-5 system failure.
  - Loss of power to the primary PLC-5 system
  - Problems with the ControlNet network which causes loss of the handshake connection with the primary processor.

  The formula that determines the length of time the secondary system waits before timing out the primary processor is as follows:

  Primary Timeout = 5 + (3 * NUT) or 25ms, whichever is greater.

  So, if the NUT is 5ms, the Primary Timeout is 20ms. If the NUT is 10ms, the Primary Timeout is 35ms.

  The Primary Timeout is not the only factor in the Timeout Switchover Time. There is also processing which must occur on the secondary system after a Primary Timeout occurs. This processing can take up to 5ms. The formula for the Timeout Switchover Time is:

  Timeout Switchover Time = Primary Timeout + 5ms.

  So, if the NUT is 5ms, the Timeout Switchover Time is equal to 25ms plus 5ms, or 30ms.

Data Table Crossloading

Chapter Objectives

This appendix provides you with reference information on the data table crossloading feature.

Data Table Crossloading

Data table crossloading is a feature you can enable to minimize the bump in system outputs when a processor switchover occurs. This feature is most useful when identical PLC-5 processors are used in the backup system.

To minimize a bump in system outputs, it is often important for the secondary processor's data table values to closely match the primary processor's data table values. This is true in control applications where output values are dependent upon other data table variables. If the data table values between the processors are different, there may be a bump in the system outputs when the secondary processor takes over from the primary processor after a switchover.

In the PLC-5 ControlNet backup system, each processor has its own data table, and values are not automatically exchanged between the PLC-5 processors. During operation, each processor simultaneously receives the same set of input data, executes its program logic, and places program logic results in its own data table. Over time, the data table values may diverge between the primary processor and the secondary processor due to such things as internal timer differences or asynchronous events such as CIO instruction completion.

Once backup system qualification is completed, there is no automatic data table crossloading from the primary processor to the secondary processor in the default PLC-5 ControlNet backup system. However, there may be applications where it is highly desirable to be able to easily and automatically crossload data table data from the primary processor to the secondary processor. To meet this need, there is a feature called On-Demand data table crossloading that greatly simplifies the transfer of data table information from the primary processor to corresponding data table locations on the secondary processor.

An On-Demand data table crossload transfers data table data from the primary processor to the secondary processor. To set up On-Demand data table crossload operations, you must load configuration information, identifying the files to be crossloaded. Then, to trigger an On-Demand data table crossload, you must enter a non-zero value into word 33 of the ControlNet Hot Backup Integer file. Functionally, an On-Demand data table crossload is equivalent to a series of Message Instructions; however, no ladder programming is required.

In addition to the crossloading mentioned above, there is Automatic data table crossloading, occurring at the time of qualification, which transfers data table values from the primary processor to corresponding data table locations on the secondary processor. This ensures that when a secondary processor becomes qualified, that processor is immediately ready to take over control of the outputs should a switchover occur.

Both the On-Demand data table crossload and Qualification data table crossload use the unscheduled bandwidth of the ControlNet channel. You can also perform data table crossloads in ladder logic, via the message instruction. When you perform data table crossloads via the message instruction, you can use any available channel; you are not limited to the ControlNet channel.

Important: Neither the On-Demand data table crossload nor the Qualification data table crossload can occur unless the data table structures are identical between the two processors.

Also, data table crossloading only crossloads data table data (i.e., there is no mechanism to crossload Program file information. It is up to you to ensure that the proper program files are downloaded into your processors.

On-Demand Data Table Crossloads

It may be necessary for you to crossload data table data after the backup system has a qualified secondary processor. For example, the Timer Accumulators may have diverged between the primary and secondary processor over time. Or, you may have modified some data table values on the primary processor and would like to copy those values into the secondary processor.

The On-Demand data table crossload only occurs when you initiate it, and can be performed only on a qualified backup system (i.e., a backup system in which there is both a primary and secondary processor).

The On-Demand data table crossload transfers specific files and subelements of files from the primary processor to the secondary processor. There are 4 different and individually selectable operations that can be performed as part of an On-Demand data table crossload. Each operation transfers a different part of the data table as shown below.

- Timer Accumulators

  When Timer Accumulators are crossloaded during the On-Demand data table crossload, only the Accumulator subelements of the Timer structures are crossloaded. Crossloading only the Accumulator subelements of the Timer structures allows the secondary processor to match the Accumulator values in the primary processor without corrupting the control bit subelements of the Timer structures in the secondary processor. All files of Timer file types are crossloaded (i.e., you cannot crossload a subset of Timer file types). Also, all file elements of each Timer file are crossloaded (i.e., you cannot crossload a subset of file elements for a particular file).

- Counter Accumulators

  When Counter Accumulators are crossloaded during the On-Demand data table crossload, only the Accumulator subelements of the Counter structures are crossloaded. Crossloading only the Accumulator subelements of the Counter structures allows the secondary processor to match the Accumulator values in the primary processor without corrupting the control bit subelements of the Counter structures in the secondary processor. All files of Counter file types are crossloaded (i.e., you cannot crossload a subset of Counter file types). Also, all file elements of each Counter file are crossloaded (i.e., you cannot crossload a subset of file elements for a particular file).

- PD Files

  The entire PD file structure is crossloaded during the On-Demand data table crossload from the primary processor to the non-primary processor. All PD files are crossloaded, as well as all elements in the PD files. You are not able to crossload a subset of PD file types (i.e., if there are 20 PD data table files, all 20 PD data table files will be crossloaded).

- User-Selectable Files

  You can select two individual files and a range of files (inclusive) to be crossloaded from the primary processor to the non-primary processor during the On-Demand data table crossload. All the elements of these files are crossloaded. There are 4 words in the ControlNet Hot Backup Integer file reserved for user-selectable On-Demand data table crossloads. You must fill in the file numbers into these 4 words for the appropriate files to be transferred. You should fill in a zero when you do not wish to perform a crossload.

  - User Defined crossload File 1 (Word 55 of the CHBI file)
  - User Defined crossload File 2 (Word 56 of the CHBI file)
  - User Defined crossload Range Low File (Word 57 of the CHBI file)
  - User Defined crossload Range High File (Word 58 of the CHBI file)

The two individual files as well as the range of files you select are crossloaded, regardless of file type. There are some notable exceptions; the following files are not be crossloaded even when you select them:

- Output Image File (File 0)
- Input Image File (File 1)
- System Status File (S2)
- ControlNet Data Output File (DOF)
- ControlNet Data Input File (DIF)
- ControlNet Backup Integer File
- ControlNet Configuration File
- ControlNet I/O Status File
- ControlNet Diagnostic File

Important: If a file in the On-Demand crossload User Selectable files is either a Timer or Counter file type, only the Accumulator for each file element is crossloaded.

Optimizing On-Demand Crossloads

When setting up the backup system, the location of the data that needs to be crossloaded is important. We recommend that you place all of the crossload data into a few consecutively-addressed files. Then, by configuring those files in the range User Selectable crossload files, only those files will be crossloaded. This shortens the time necessary to perform the crossload, as well as preventing unwanted files from being crossloaded.

For example, if there are 10 integer files that need to be crossloaded, place those 10 integer files into consecutively numbered files (e.g. N100 through N109). Then fill the User Defined Crossload Range Low File (Word 57 of the CHBI file) with 100 and the User Defined Crossload Range High File (Word 58 of the CHBI file) with 109. Now all 10 integer files will be crossloaded when User Selected File operation of the On-Demand data table crossload is triggered.

Triggering an On-Demand Data Table Crossload

On-Demand data table crossloads are initiated by writing a value into the On-Demand crossload command word (word 33 of the ControlNet Backup Integer File). The On-Demand data table crossload can be initiated from either the primary or secondary processor.

Since the On-Demand crossload command word is located in an integer file, you have many options concerning how the On-Demand data table crossload gets triggered. The crossload could be triggered via the ControlNet Backup Configuration and Status tool, via the RSLogix5 Data Monitor, or via ladder logic in your application.

The On-Demand data table crossload operations that get performed depend on the value written into the On-Demand Crossload Command word. The 4 least significant bits of the On-Demand Crossload Command word are defined for the 4 different On-Demand data table crossload operations.

- Bit 0 - Timer Accumulators
- Bit 1 - Counter Accumulators
- Bit 2 - PD elements
- Bit 3 - User Selected Files

Thus, if you wrote a 15 (binary 1111) into the On-Demand Crossload Command word, all On-Demand State crossload operations would be performed. If you wrote a 5 (binary 0101) into the On-Demand Crossload Command word, only the Timer Accumulators and the PD elements would be crossloaded.

When the On-Demand State crossload is started, the On-Demand Crossload Command word is cleared by the processor. While the On-Demand State crossload is active, the processor ignores the On-Demand Crossload Command word. This is true even if the On-Demand State crossload was started from the other processor. When an active On-Demand State crossload finishes, the processor then checks to see if a new crossload command is in the On-Demand Crossload Command word.

Qualification Crossloads

There are two separate crossloads that are automatically performed during qualification. These qualification crossloads are only done if the data table structures are identical between the two processors. The first crossload performed during qualification is the Qualification data table crossload. This crossload is performed when the processor is still in Program mode. The second crossload done during qualification is the Qualification State data table crossload. This crossload is performed once the processor has transitioned into Run mode. Even though the processor has transitioned into Run mode, qualification is not complete until the Qualification State data table crossload is complete.

Qualification Data Table Crossload

The Qualification data table crossload occurs when a processor in the No Control state transitions from Program mode to Run mode, and the other processor is the primary processor. This complete data table crossload is performed while the qualifying PLC-5 system is still in Program mode. It is necessary to remain in Program mode until the complete data table crossload is finished in order to prevent the qualifying system from major faulting or going off into an odd state due to uninitialized data table values.

All elements of all data table files are crossloaded in the Qualification data table crossload with the exception of the following files. These files cannot be crossloaded because they contain processor-specific configuration and status information.

- System Status File (S2)
- ControlNet Backup Integer File
- ControlNet Configuration File
- ControlNet I/O Status File
- ControlNet Diagnostic File
- ControlNet Data Output File (DOF)
- ControlNet Data Input File (DIF)

Although the System Status File is not crossloaded, the real time clock (6 words) in the System Status File is crossloaded from the primary processor to the partner processor.

Qualification State Data Table Crossload

Even though a Qualification data table crossload has occurred during qualification, some of the crossloaded data may have become stale. This is because the Qualification data table crossload occurs while the processor is in Program mode. For example, if the Qualification data table crossload takes 10 seconds, the data in the original data table file that was transferred is 10 seconds old. In order to bring certain state information in the data table up to date, a Qualification State data table crossload is performed.

The Qualification State data table crossload occurs when the qualifying processor has transitioned into Run mode, but before the qualifying processor has become qualified.

The Qualification State data table crossload is almost identical to the On-Demand data table crossload discussed previously. The only differences are:

- the Qualification State data table crossload occurs automatically during qualification whereas you must trigger the On-Demand data table crossload
- the Qualification State data table crossload always performs all four crossload operations (Timer Accumulators, Counter Accumulators, PD files, and User Selectable files), whereas the On-Demand data table crossload allows you to select which combination of the four operations get performed

Data Table Crossload Time

It may take many seconds for any of the above instances of data table crossloading to finish. The time it takes to do the data table crossload primarily depends on the amount of data table data to be crossloaded. The data table crossload is performed using the unscheduled bandwidth of the ControlNet channel. The amount of available unscheduled bandwidth on the ControlNet channel also influences the amount of time needed to perform the data table crossload.

There are two words which indicate how long it takes the data table crossload to finish: one for the Qualification data table crossload (word 50 in the ControlNet Backup Integer File), and one for the most recent occurrence of either the On-Demand data table crossload or the Qualification State data table crossload (word 51 in the ControlNet Backup Integer File). The time units are in milliseconds.

Data Table Crossload Data Latency

Even though a data table crossload may take many seconds to complete, the data that is transferred from the primary processor to the qualifying or secondary processor is fresh. In other words, the crossloaded data is not sitting in a buffer getting stale waiting for all the data to be crossloaded. Each packet of data is immediately written into the other processor's data table. So, no matter how long the data table crossload takes, the data table elements which are crossloaded into the qualifying or secondary processor closely match the values in the primary processor.

Effect of Data Table Crossloading on the ControlNet Channel

Data table crossloading only transfers one file at a time. Also, only one unscheduled buffer is used at any one time. So the impact of the data table crossloading on available ControlNet channel unscheduled bandwidth should be minimal. Also, the impact of data table crossloading on the available unscheduled buffers is minimal.

Inhibiting Data Table Crossloads

All crossloading is inhibited if there is any difference at all in the data table structures between the two processors. This inhibits all data table crossloads, not just data table crossloads to files whose structures differ between the two systems.

You can make the data table structures differ between the two systems by creating an extra data table file on one of the systems, or by increasing the size of one of the data table files.

For a qualified backup system, you are given an indication as to whether the data table structures match in the Equivalence Check Error word (word 49 of the ControlNet Backup Integer File) bit 1.

You can ensure that the qualifying system fails qualification and major faults if the data table structures do not match by enabling data table Equivalence checking.

Data Table Crossload Diagnostics

There are some words reserved in the ControlNet Backup Integer File for data table crossload diagnostics. First, there is a data table crossload active word (word 52 in the ControlNet Backup Integer file). This word is non-zero whenever a data table crossload is active. This word is zero whenever a data table crossload is inactive.

When a data table crossload fails, diagnostic information is stored in 2 words of the ControlNet Hot Backup Integer (CHBI) file. Word 54 of the CHBI file contains the file number of the crossload that failed. Word 53 of the CHBI file contains the error code indicating the reason why the crossload failed. These error codes are identical to the Message Instruction Error Codes. See the Instruction Set Reference Manual (Publication 6200-6.4.11) for a complete listing of the various error codes which can be encountered while executing a Message Instruction.

For example, a qualification crossload could fail if the data table file on the primary processor had read privileges disabled. This error would show up as error code 0xF00B (privilege error) in word 53 of the CHBI file.

Performing Data Table Crossloads Via Your Applications

On-Demand data table crossloading greatly simplifies the whole crossloading procedure. However, you may have some special crossloading needs that are not covered by On-Demand data table crossloading. For example, if you want to crossload the data table data over the Ethernet channel instead of the ControlNet channel, you cannot use On-Demand data table crossloads. Or, perhaps you only need to crossload certain elements within a file instead of the whole file. Or, even if you need to crossload the entire Timer structure instead of just the Accumulator subelement, On-Demand data table crossloads do not meet those needs.

You can always perform your own data table crossloads using message instructions. These message instruction crossloads can be used in conjunction with On-Demand data table crossloads or they can be performed separately. You are not limited to doing these data table crossloads over the ControlNet channel.

We recommend that you have the message instruction rung qualified with the backup state of the processor (e.g. secondary backup state). Then the instruction will only be executed when the processor is a secondary. A bit instruction can be used to condition the rung. Word 3 of the ControlNet Hot Backup Integer file contains the backup state of the processor. Bit 2 is set if the processor is the primary. Bit 3 is set if the processor is the secondary.

Program Synchronization

Chapter Objectives

This appendix provides you with reference information on the program synchronization feature.

Program Synchronization

Both processors in a ControlNet PLC-5 backup system execute their own program logic. You can configure the ControlNet PLC-5 backup system to have either Asynchronous program scans or Synchronous program scans. Asynchronous mode allows the program scans on the two processors to run as if they were stand-alone processors. When a program scan on a processor is finished, housekeeping is performed, and the next program scan is immediately started. The program scan on one processor is completely independent of the program scan on the other processor.

Synchronous mode provides both program scan synchronization as well as housekeeping synchronization. When a program scan on a processor is finished, housekeeping is delayed until a synchronization point is reached. This synchronization point is the same for both processors. Housekeeping is then performed at the same time on both processors. By having housekeeping performed at the same time, both processors should be updating the Input Image Table with the same input values. When housekeeping is finished, the program scans then immediately start and the cycle repeats itself. Synchronous mode allows the inputs used by the two backup processors to closely match each other, as well as forcing each program scan to begin at the same time.

Synchronous mode offers only one synchronization point per program scan. After the synchronization point is passed, the two control programs run asynchronously until the next synchronization point during the next housekeeping.

When the ControlNet backup system is configured in Asynchronous mode, the Sync LED is off. When the ControlNet backup system is configured in Synchronous mode, the Sync LED is either solid green or solid red.

Determining Which Mode to Use

Determining whether to select Asynchronous mode or Synchronous mode depends on your application. If the program logic is completely different between the two processors, it is appropriate to select Asynchronous mode. Also, if the program scan time frequently bumps out from a small value to a very large value so that the configured Maximum Program Scan Time is too large for the application, it would be appropriate to select Asynchronous mode.

On the other hand, if the program logic between the two processors is identical or very similar, and if the configured Maximum Program Scan Time is small enough for the application, it is advantageous to select Synchronous mode. Synchronous mode minimizes data table divergence between the two processors, resulting in bumpless switchovers.

Using Synchronous Mode

There are two considerations to keep in mind when using synchronous mode. First, synchronous mode requires you to determine the Maximum Program Scan Time. There is no formula to determine the maximum program scan time for a particular program; you must determine this value through running the application in its real environment.

Second, in Synchronous mode, each program scan is always lengthened to be equal to the maximum program scan time. Thus, even when a particular program scan takes only a fraction of the maximum program scan time, the program scan waits until the synchronization point is reached before continuing with housekeeping. Depending on your application and program logic, this may affect overall system throughput.

Determining the Maximum Program Scan Time

When configuring Synchronous mode, you must enter the Maximum Program Scan Time (in ms). The Maximum Program Scan Time is a time that should not be exceeded by the program scan. The program scan is the time it takes the processor to execute the logic program once, perform housekeeping tasks, and then start executing logic again.

Because every program scan is pushed out to the Maximum Program Scan Time, it is advantageous to configure the Maximum Program Scan Time parameter to be as close to the largest program scan time as possible. The only way to determine the largest program scan time for a particular application is to run the application in Asynchronous mode under all conditions and then determine what the largest program scan time was. You can determine this by viewing the Status File word S:9. Be sure to consider all the events that may cause the program scan time to temporarily increase such as PII's, STI's, On-line edits, etc..

Adjusted Maximum Program Scan Time

The Maximum Program Scan Time parameter you enter for Synchronous mode gets adjusted before being used by the ControlNet PLC-5 Backup system. The Adjusted Maximum Program Scan Time is equal to the smallest integer number of NUT's whose time value is greater than or equal to the Maximum Program Scan Time parameter. For example, if the configured Maximum Program Scan Time parameter is 65ms and the ControlNet channel NUT value is 10ms, the Adjusted Maximum Program Scan Time would be 70ms (i.e. 10ms x 7). In this example, each program scan time would be fixed at 70ms.

Program Scan Overrun

For Synchronous mode operation, it is possible for the actual program scan time to exceed the Adjusted Maximum Program Scan Time. When this overrun condition occurs, the Sync LED turns solid red and the Maximum Program Scan Time Exceed Counter (word 48 in the ControlNet Backup Integer File) is incremented. You must zero out the Maximum Program Scan Time Exceed Counter for the Sync LED to turn from solid red to solid green. The Maximum Program Scan Counter is cleared by writing a non-zero value into the Reset Diagnostic Counters word (word 32 of the ControlNet Hot Backup Integer file).

When a program scan overrun occurs, the two processors temporarily go out of sync, however they do not stay out of sync. They go back into sync at the earliest time possible. They should be back into sync at the next housekeeping. Even when the processor are resynchronized, the Sync LED remains solid red until you clear the Maximum Program Scan Time Exceed Counter.

Should frequent program scan overruns occur, it may be necessary for you to increase the Maximum Program Scan Time parameter. The Maximum Program Scan Time parameter can be changed "on-the-fly" to the primary processor while the processor is in RUN mode. Both processors will automatically begin using the new Adjusted Maximum Program Scan Time parameter.

Application Guidelines

Chapter Objectives

This Appendix will provide you with application examples, as well as information on other items to consider while operating your ControlNet PLC-5 hot backup system.

Redundancy Considerations

The PLC-5 system for redundancy is designed to allow a secondary PLC processor to take over I/O and system control from a primary PLC processor which has become disabled. The main goal in designing a redundant PLC system is to ensure that the secondary processor executes as closely as possible to the primary system. That way, when control is transferred from the primary to the secondary, the transfer is seamless (or bumpless), meaning that the outputs of the system are maintained in the same state after switchover occurs.

When the systems produce radically different outputs based on different data table variables, divergence occurs. When divergence occurs, outputs may change state when control is transferred from primary to secondary. To minimize divergence, state information must be transferred from the primary processor to the secondary processor. Much, if not all, of the information transfer between the primary and secondary processors can be performed automatically by the secondary processor.

Depending on the design of the PLC application program, additional information may have to be exchanged by the application program in order for the secondary system to be in the same state as the primary. You can accomplish this information exchange, if necessary, simply by adding a PLC-5 message instruction in the secondary system.

Switchover Considerations

The following sections provide information on factors you should keep in mind when performing a switchover.

Why Transfer Information?

When the primary PLC processor is operating, system outputs are a function of current and prior I/O events. Outputs may be in the present state because a current input condition requires a certain output state. If the secondary system comes online and senses the input condition, it will place its output in the same state. If a switchover occurs, so that the secondary becomes primary, system control switches over seamlessly because the new primary maintains the output in the present or current state.

System outputs are, in many cases, a function of past events or states. An output may be in the present state based on a timing event, a counting event, or some other prior event. If the secondary comes online and immediately assumes control, its outputs are likely to be in an opposite state from the primary because the secondary was not in operation while the primary was accumulating the past events. In order to ensure seamless switchover of control, the secondary should be refreshed with the primary's past events before assuming control.

The ControlNet PLC-5 backup system transfers many system state variables automatically. In addition, the secondary transfers the entire primary data table on power up. Upon entering Run mode, the secondary transfers all timer accumulators, counter accumulators, PD file type structures, and selected files (which you have specified) a second time. This transfer places these critical state variables in the freshest state possible. In most applications, you can transfer all necessary information by configuring a few parameters in the ControlNet Hot Backup Configuration file. The secondary PLC processor uses the configuration parameters to determine which files to transfer.

What Information Should Be Transferred?

The secondary PLC processor transfers selected processor memory files on power up. Timers, counters, and PID structures contain past state information, so these critical state variables are automatically transferred. You can also select a range of files to transfer by entering the beginning file number and ending file number in the configuration parameters. In addition to the file range, you can specify a limited number of selected files for transfer. By setting the appropriate bit in the transfer register, the secondary processor transfers timers, counters, PD structures, and/or the files you have selected. When the secondary transfers these files, the transfer bits are cleared by the secondary, and no further transfers take place until the transfer bits are once again set by the secondary PLC application program.

While the transfer register can, in most cases, function as the sole mechanism for transferring state files, other information may still need to be transferred. For instance, an integer file may be used as a past event holder in some applications. If this file can cause the state of the primary and secondary to be different, you may wish to transfer the integer file just shortly after entering Run mode. The additional transfer may be necessary even though all of the primary processor’s data table is transferred on power up. This transfer may be necessary because there can be a time delay between the time that the entire data table is transferred and the time the secondary actually goes into Run mode. It is possible for one of the state variables to change on the primary while the secondary acquires the past state information.

Other state variables include the control registers used in FAL, Diagnostic, Sequencing, FSC, FIFO, and Fill instructions. The control registers are stored in file type R (e.g., R6:0). All of these variables are transferred upon power up of the secondary PLC. Many of these instructions operate in All mode. In other words, the instruction begins and completes within a program scan, and the instruction control register is armed for reset on the next enable condition. All mode execution of instructions typically does not raise different state issues between primary and secondary because both programs begin and execute the instruction to completion upon the enabling event. Therefore, the instructions are synchronized to produce the same outcome.

Many of the above instructions can also operate in incremental mode. In other words, each time the instruction is enabled, the control register counter is incremented. Instruction completion depends either on the instruction reaching the end-of-file condition or upon satisfying the instruction's purpose (e.g., a File Search and Compare finds a matching word and stops). Any instruction that takes several program scans for completion may be a candidate for transfer to the secondary because past event information is recorded in the control register. If the secondary begins execution with the control register at a different point than the primary, the secondary data table may diverge from the primary since its instruction is behind the primary.

When Should the Information Be Transferred?

The primary data table is transferred at power up. Then, selected state variables are transferred again to account for transfer delays in updating the secondary. If nothing else occurs, the primary and secondary operate independently. There are some opportunities, however, for the processors to diverge over time. For instance, timers in both systems run off of different system clocks. Over time, these clocks may drift apart, causing the timer values to diverge. You should periodically update Timers setting the appropriate transfer bit in the transfer register. You should update, as necessary, other variables not accounted for by the transfer register via a message read instruction in the secondary program.

How Often Should the Information Be Transferred?

Since timers may diverge with time, you should periodically refresh them, thereby synchronizing the secondary with the primary. Since ControlNet bandwidth is important, it is probably adequate for you to complete this refresh on a daily or weekly basis. A PLC program should not simply continue to set the transfer bits to cause continuous updating after the secondary has completed a transfer. We recommend that you set up a daily or weekly counter that occasionally toggles the transfer bit.

Performance Considerations

One approach to redundant system design is to transfer as much of the primary data table to the secondary as possible and as frequently as possible. This approach is not required and actually lowers the overall performance of the system. First, ControlNet bandwidth is lowered because much more unscheduled message traffic is used to transfer data. Secondly, because of transfer delays in getting information to the secondary, many instructions are updated with stale primary information when the secondary is, in fact, perfectly synchronized with the primary.

For example, PID instructions are updated at power up of the secondary so that the secondary PID output variable quickly catches up with the primary output variable. The next time the PID is executed by the primary and secondary, both PLC processors calculate the next output, based on the current value of the input variable which both PLC processors acquire from ControlNet at the same time. Since both PID outputs are a function of the same input conditions, both PLC processors produce the same outputs independently. There is no need to transfer PID variables after the initial transfers on power up.

Most variables in a PLC system can be traced to some input condition. Once the secondary is refreshed after power-up, the secondary tracks the primary because the secondary executes upon the same input conditions as the primary. The main exception to continuous transfer is with timer variables. You should periodically, but not continuously, refresh variables.

Comparison to the 1785-BCM System

Chapter Objectives

This appendix provides you with a comparison between the ControlNet PLC-5 backup system and the 1785-BCM backup system.

Comparison to the BCM System

Like the BCM scheme, the ControlNet PLC-5 backup system makes use of a primary and a secondary processor, where both the primary and secondary processors simultaneously execute their control logic. However, these two backup schemes differ in 3 major ways:

- The ControlNet PLC-5 backup system offers the capability of synchronizing each control program scan with the scheduled input data, while the BCM backup system does not offer any form of program synchronization. With synchronized program execution and scheduled inputs, the primary and secondary systems should not diverge to any great degree. Thus the ControlNet PLC-5 backup system eliminates the need for massive crossloading of data and elaborate application program development to eliminate divergence of the primary and secondary systems.
- The ControlNet PLC-5 backup system eliminates the need for the massive wiring required in the BCM backup system. The 1794 FLEX I/O Adapters on the ControlNet channel are able to listen to data transmissions from both processors, as well as determine which processor has primary control. Also, the ControlNet producer/consumer architecture allows for input data to be broadcast to and shared by both processors. There is no special wiring required to implement ControlNet PLC-5 backup system as opposed to a standalone system, other than connecting the second processor onto the ControlNet network.
- The ControlNet PLC-5 backup system offers a simple mechanism to crossload data. The BCM backup approach requires complicated block transfer application programming in order to crossload data.

In terms of how data is provided to the two PLC-5 systems, similar to the BCM system, the ControlNet PLC-5 backup system does automatically present the ControlNet input data (both discrete and analog) to both PLC-5 processors. Unlike the BCM, however, the ControlNet PLC-5 backup system does NOT provide the remote output data (discrete and analog) to both processors. The secondary processor in the ControlNet PLC-5 backup system system generates its own output data based upon internal program execution. Should you wish to do so, you can develop and implement message instructions to crossload output data from one PLC-5 processor to the other.

Another difference in the two backup systems is that the ControlNet backup system does NOT provide a Customer Relay.

Because of the system architecture, it is possible with the ControlNet backup system to have MMI devices actively communicating with both the Primary and Secondary PLC-5s.

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